# Transportation Systems 2004 Workshop

Ft. Lauderdale, FL

# Mineral Aggregates For HMA Airfields

David Jahn

Martin Marietta Materials

# Coarse Aggregate Requirements (> 4.75 mm No. 4 Sieve)

- L A Abrasion- max 40%
- Magnesium sulfate- max 18%
- Two fractured faces- min 75%
- Flat & elongated- max 20% 3:1
- Air cooled, blast furnace slag- min 75 lb/cu ft
- Clay lumps and friable particles- 0.3% max

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Granites can be used with abrasion loss in the 50 to 55 range.

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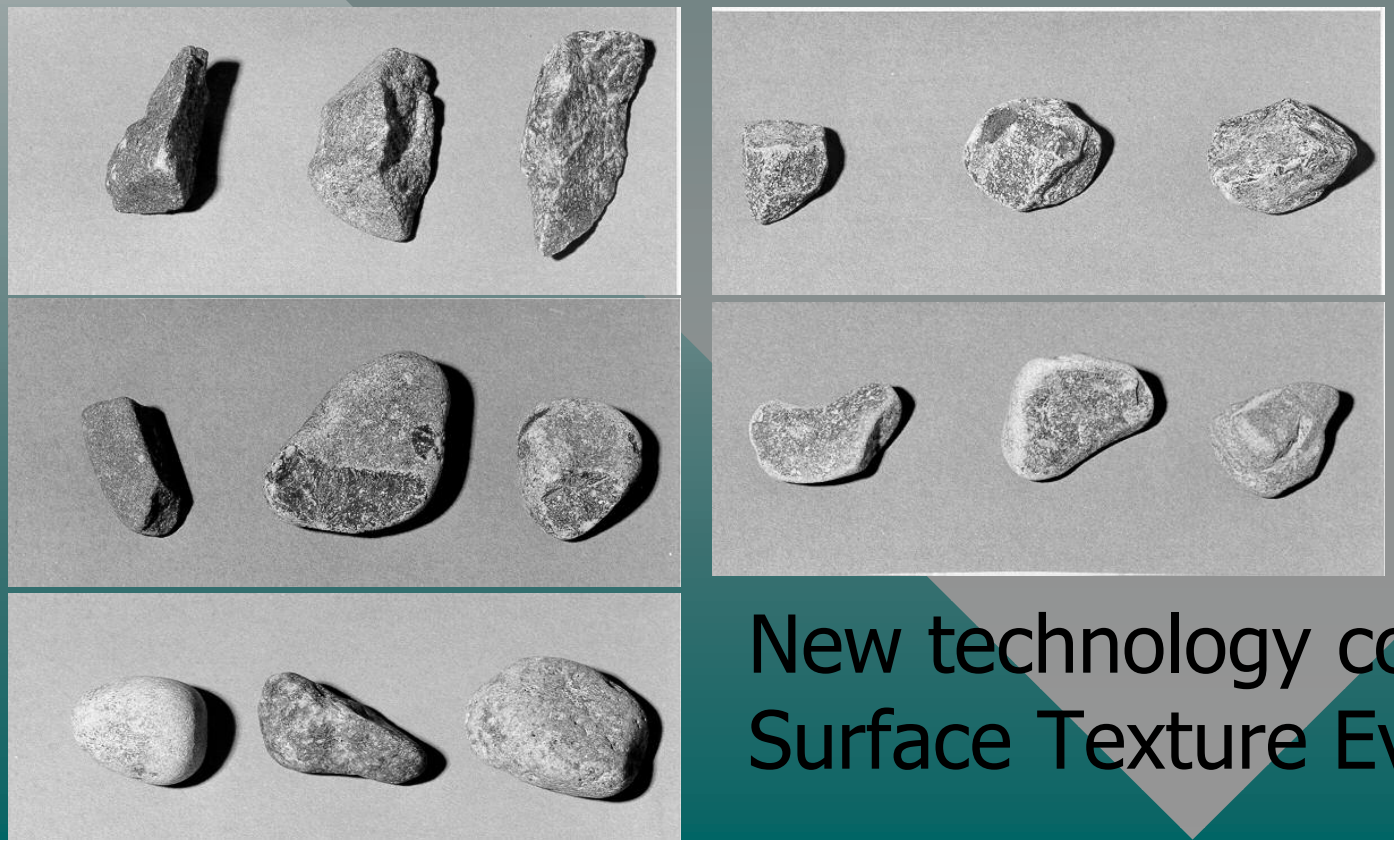
Many DOT's use the Sodium Sulfate test- there could be limited experience with Mg Sulfate testing.

# Coarse Aggregate Requirement (> 4.75 mm No. 4 Sieve)

- Two fractured faces- min 75%



New technology coming- Surface Texture Evaluation

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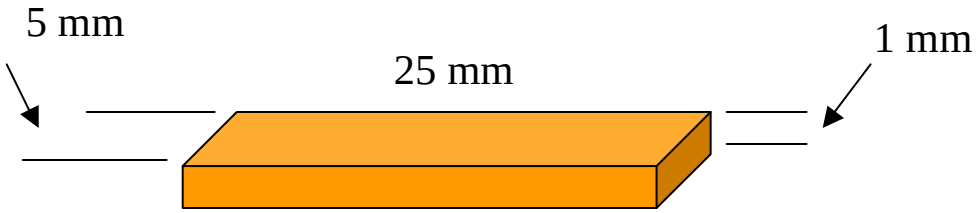
Premium Particle Shape!

# Particle Shape Evolution



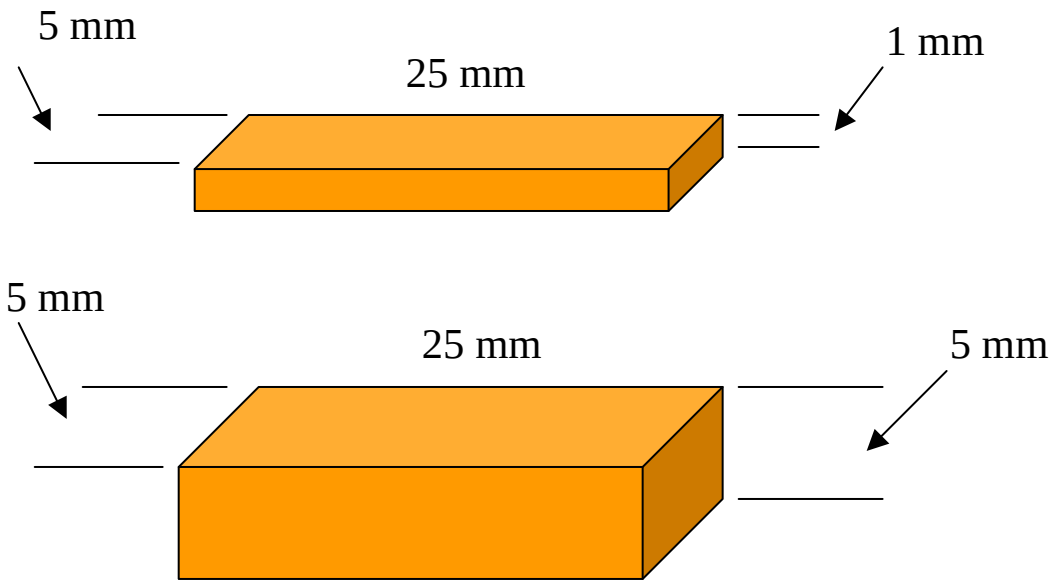

5:1 Flat ***Or*** Elongated

(Length to width)

(Width to thickness)

10% max at a 5:1 ratio is industry standard

# Particle Shape Evolution




5:1 Flat ***Or*** Elongated

(Length to width)

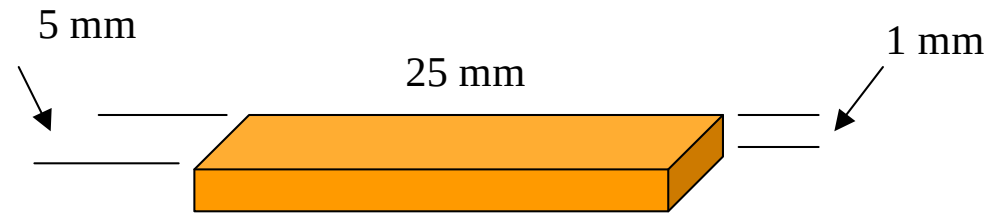
(Width to thickness)

5:1 Flat ***And*** Elongated

(Length to thickness)

Superpave specifications altered the test procedure

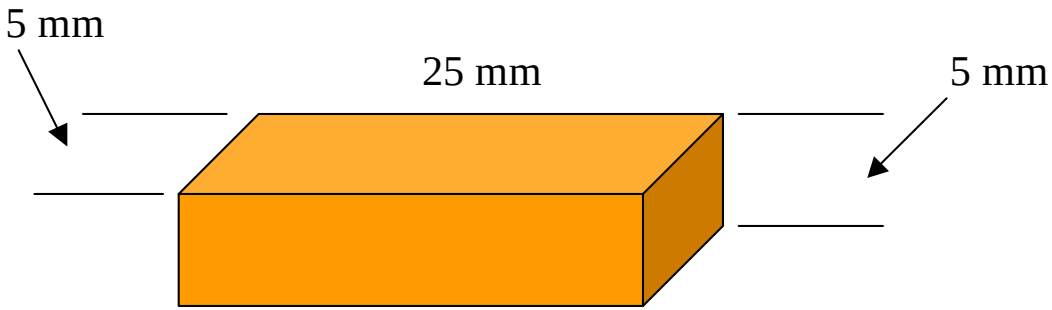
# Particle Shape Evolution




5:1 Flat ***Or*** Elongated

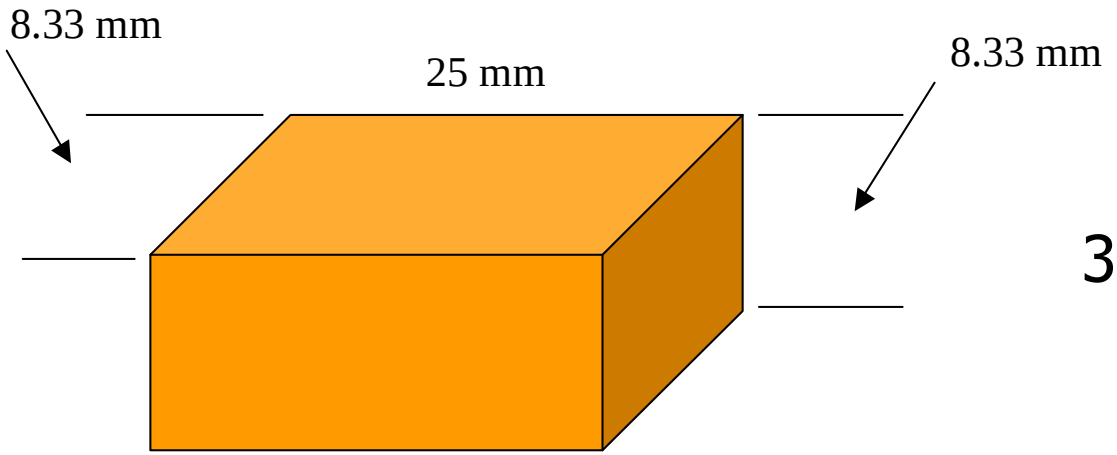
(Length to width)

(Width to thickness)




5:1 Flat ***And*** Elongated

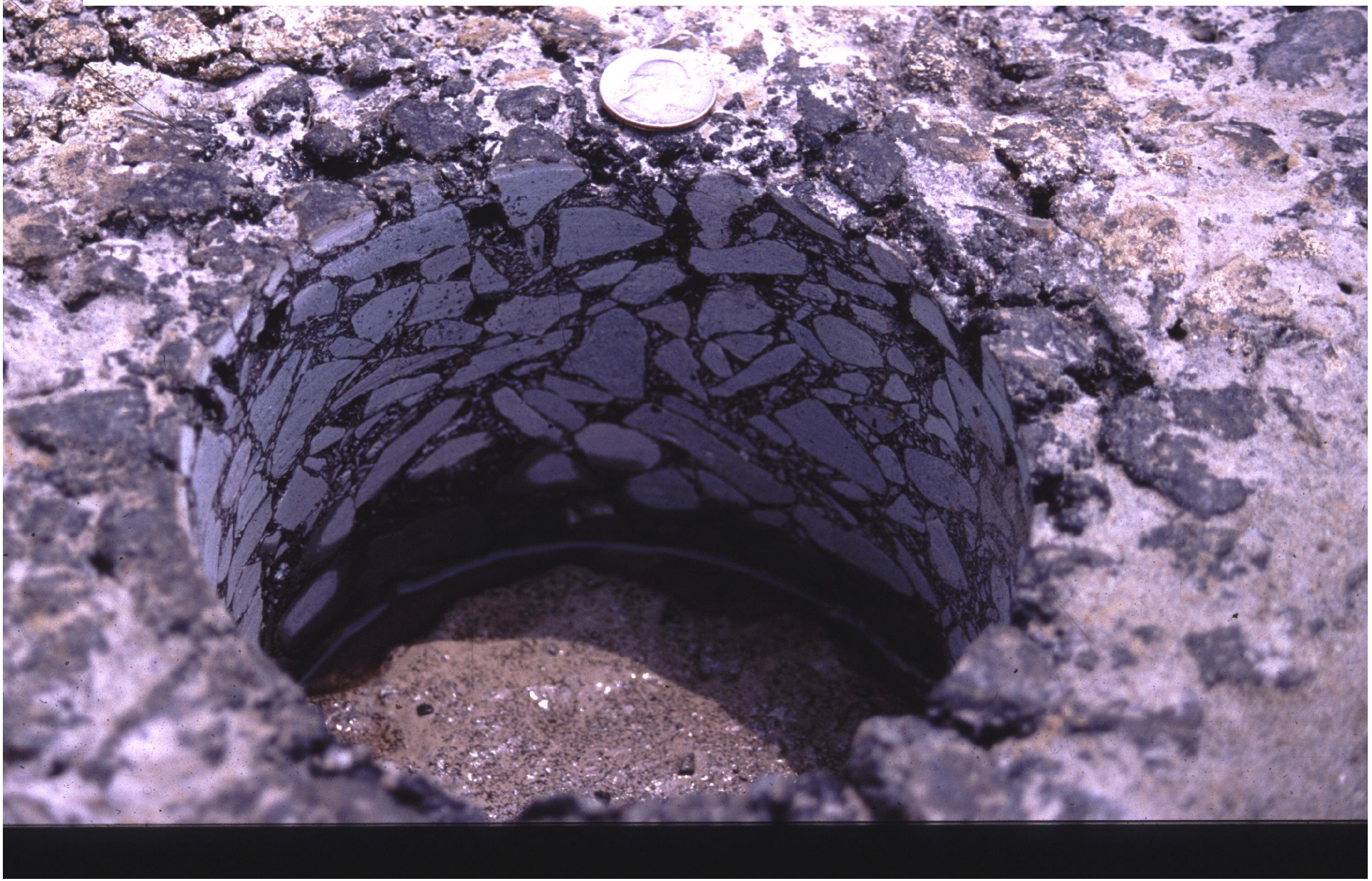
(Length to thickness)




3:1 Flat ***And*** Elongated

(Length to thickness)

Coarse graded Superpave mix placed in 1996 that is still performing well with heavy truck traffic.



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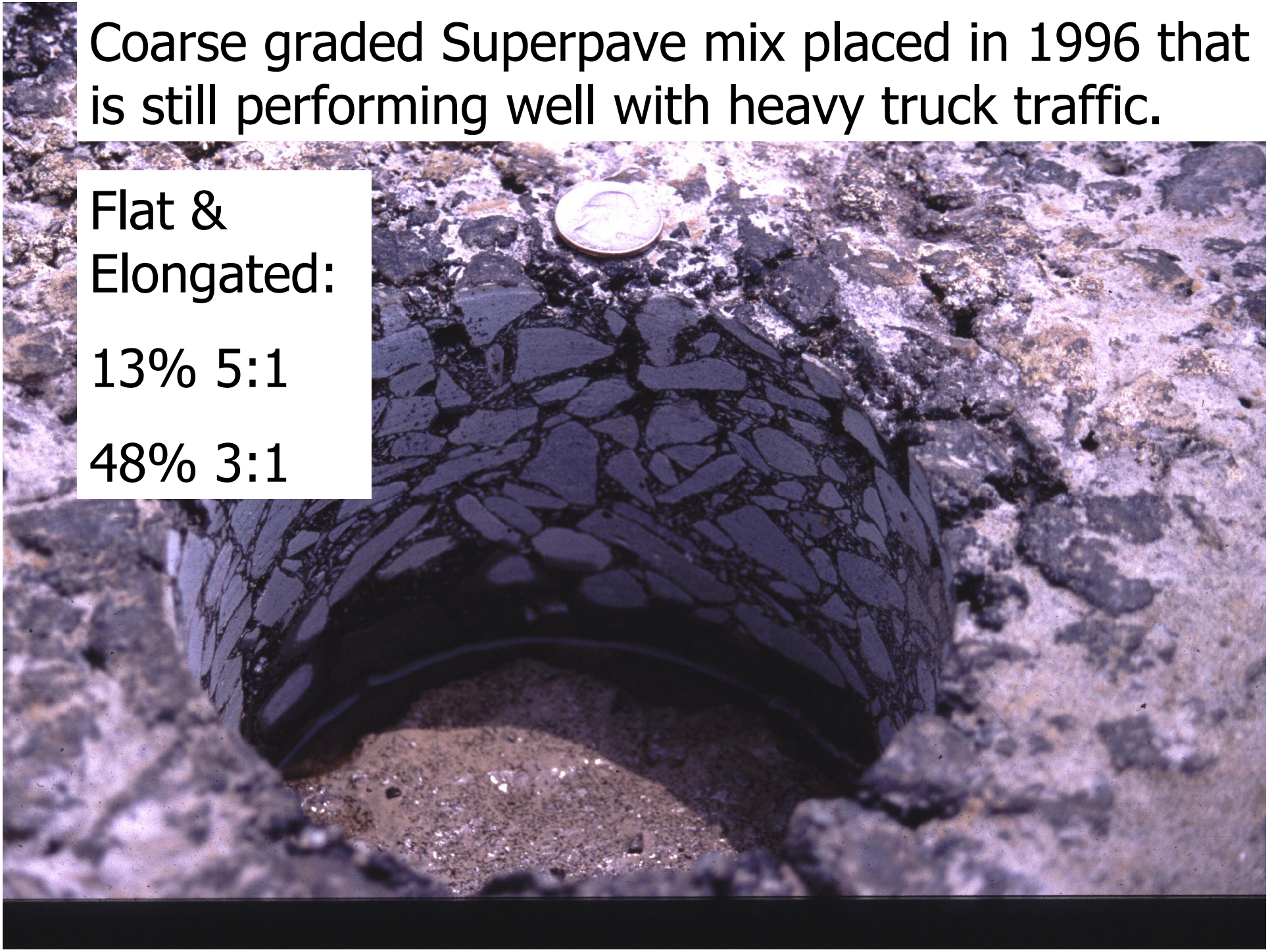
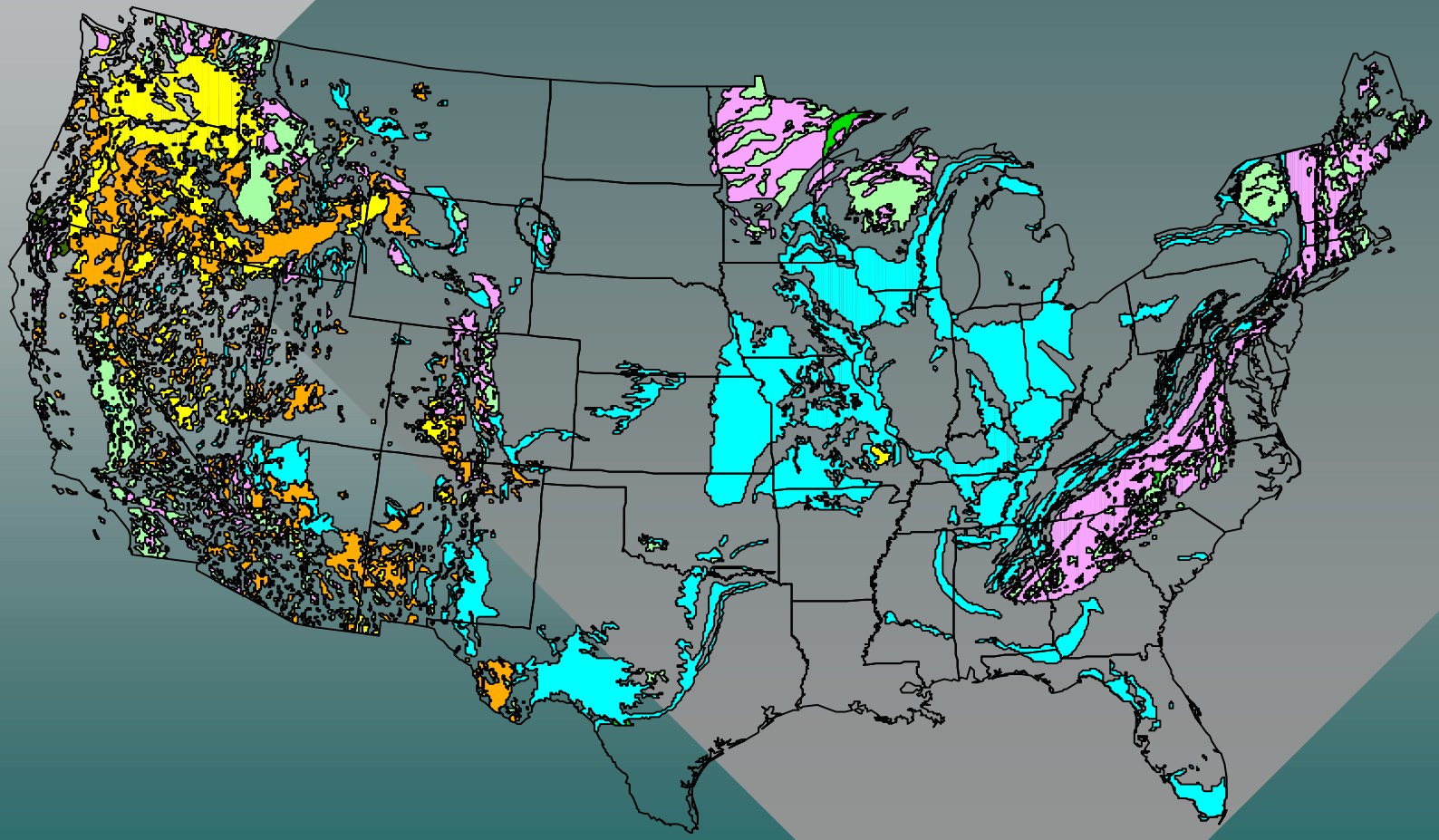


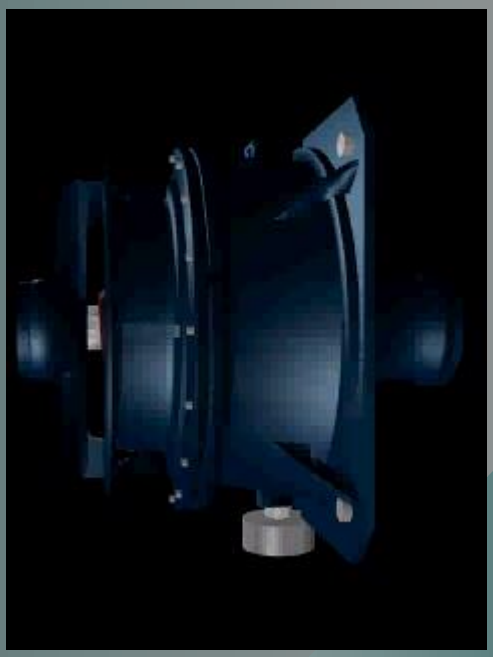
Flat & Elongated:

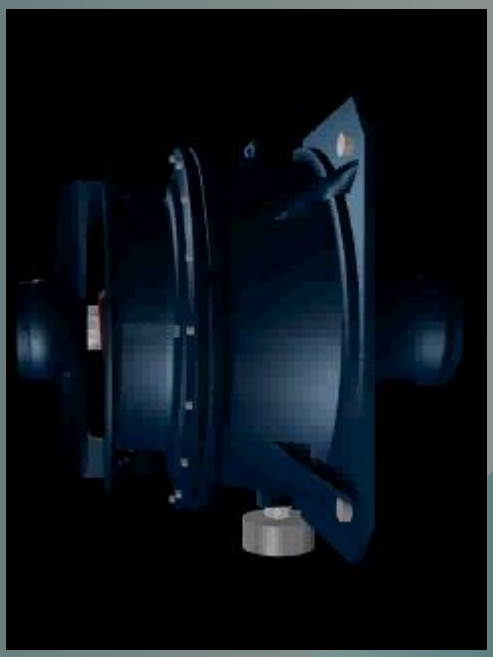
13% 5:1

48% 3:1

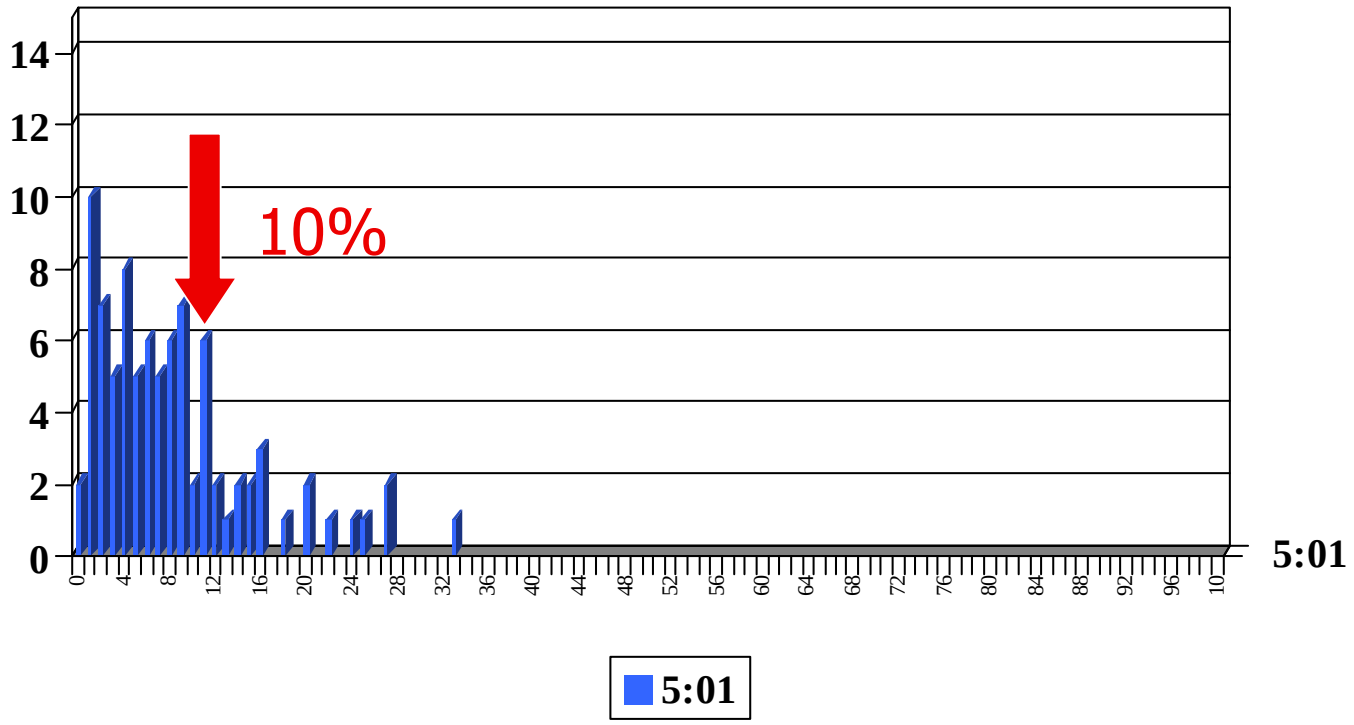
# Surface Geology





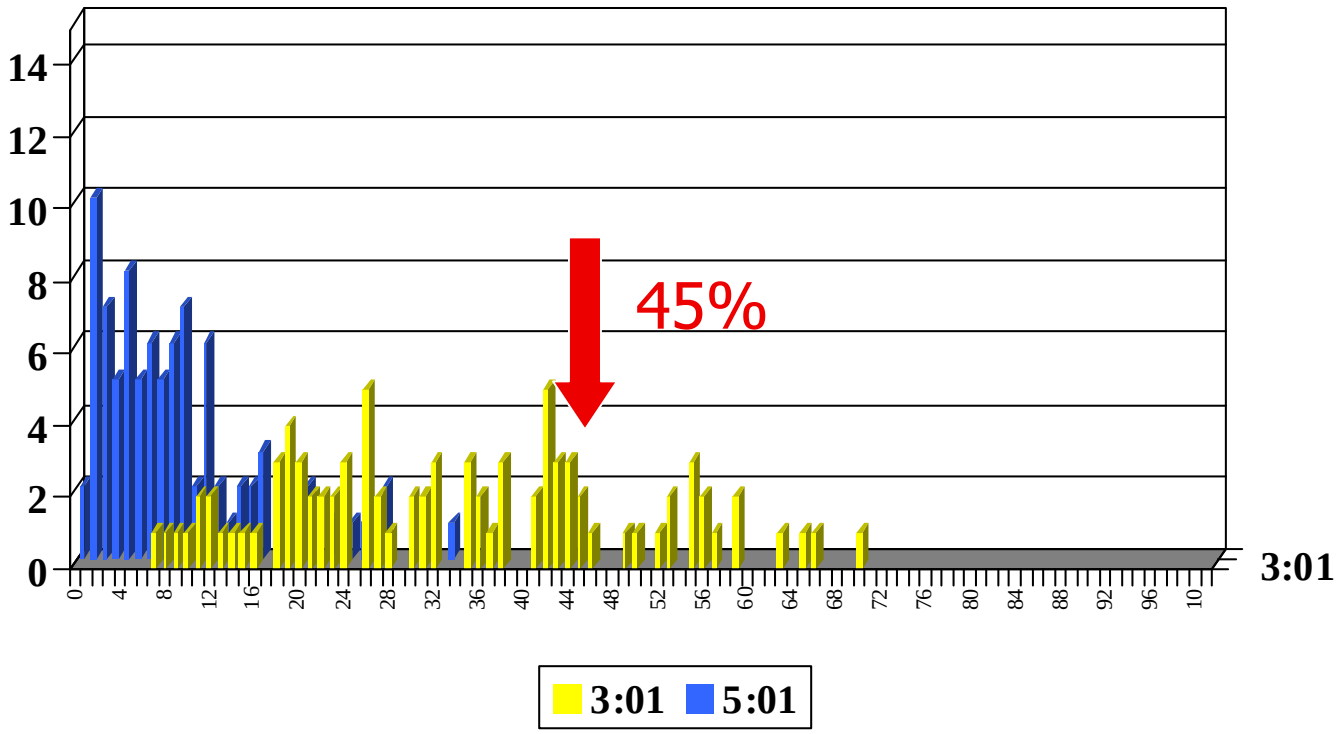


# Virginia DOT Flat and Elongated Data
# ASTM #8 Product Size




About 80% of samples pass the 5:1 ratio at 10%

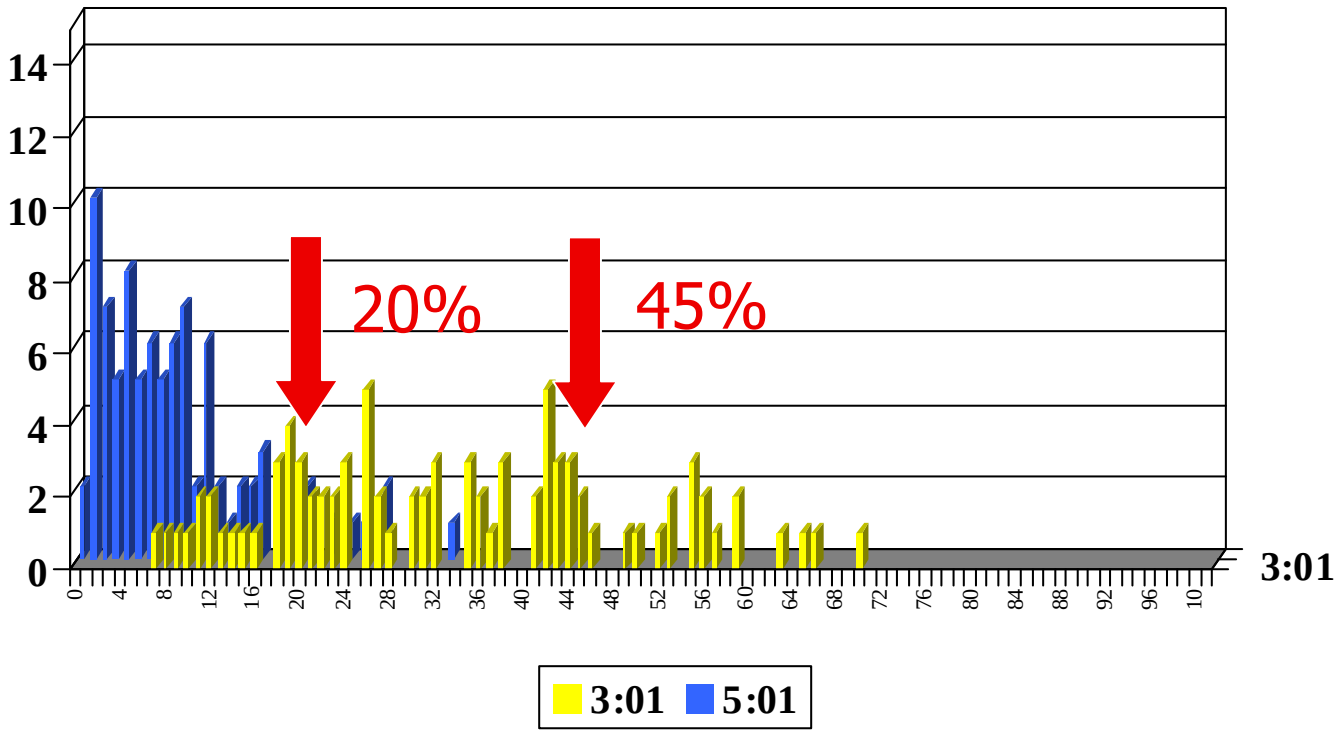
# Virginia DOT Flat and Elongated Data
# ASTM #8 Product Size




About 80% of the samples pass the 3:1 ratio at 45%.

**10% 5:1 is equivalent to 45% 3:1**

# Virginia DOT Flat and Elongated Data
# ASTM #8 Product Size




There is a significant difference in particle shape between these two values. In some geographic areas, sources at 20% may be limited.

# Evaluation of Aggregate Gradation
(% Passing)

**1/2**

**35**

# Performance ?

**1/2**

**35**

# Evaluation of Aggregate Gradation
(% Passing)

| 1 | 3/4 | 1/2 | 3/8 | #4 |
|---|---|---|---|---|
| 97 | 81 | 35 | 14 | 2 |

# Flat & Elongated Ratio

**>5:1**

**3**

# Flat & Elongated Ratio

**>3:1**

**30**

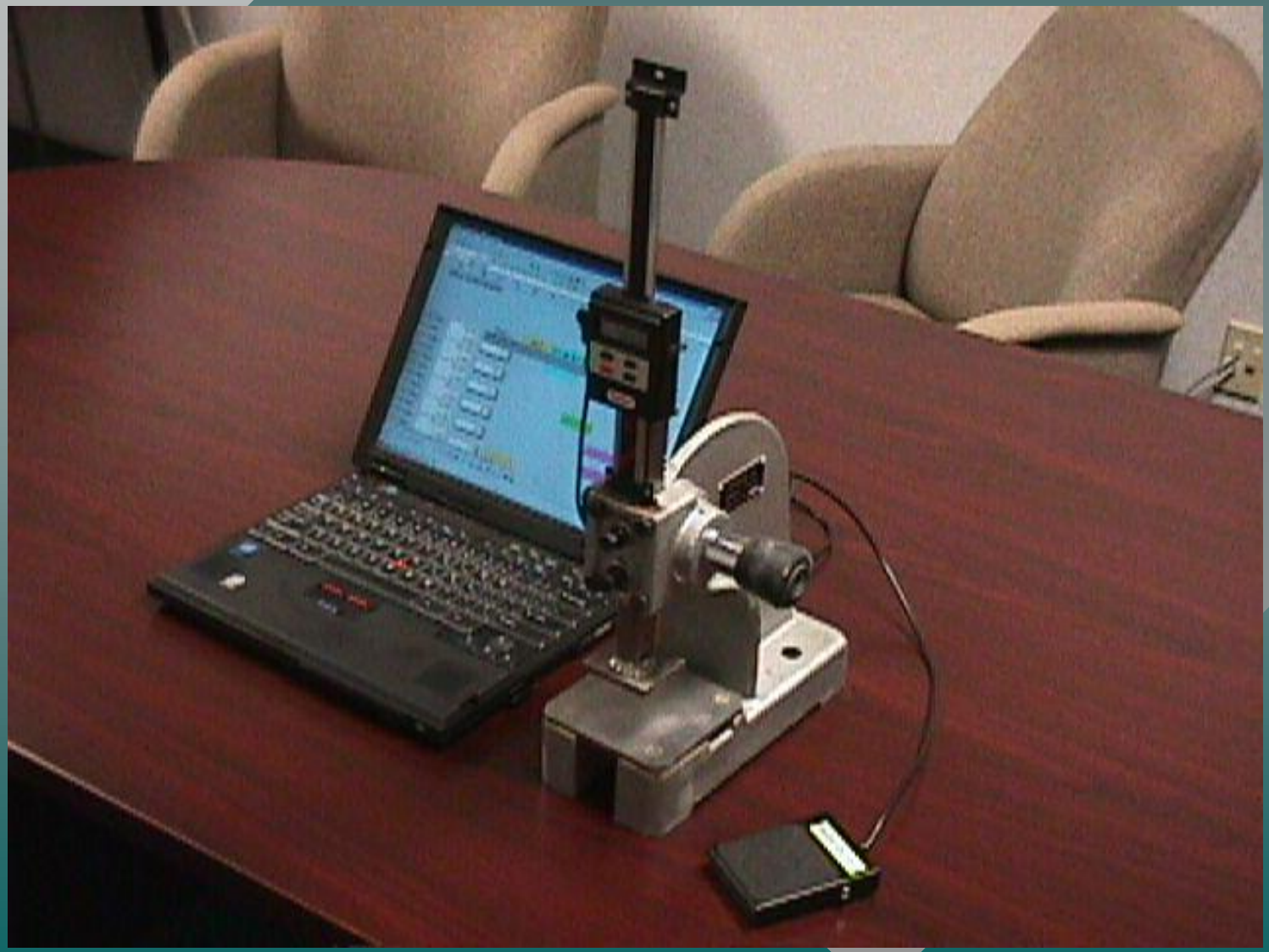
# Flat & Elongated *Ratios*

| <2:1 | 2:1 to 3:1 | 3:1 to 4:1 | 4:1 to 5:1 | >5:1 |
|---|---|---|---|---|
| 28 | 42 | 17 | 10 | 3 |

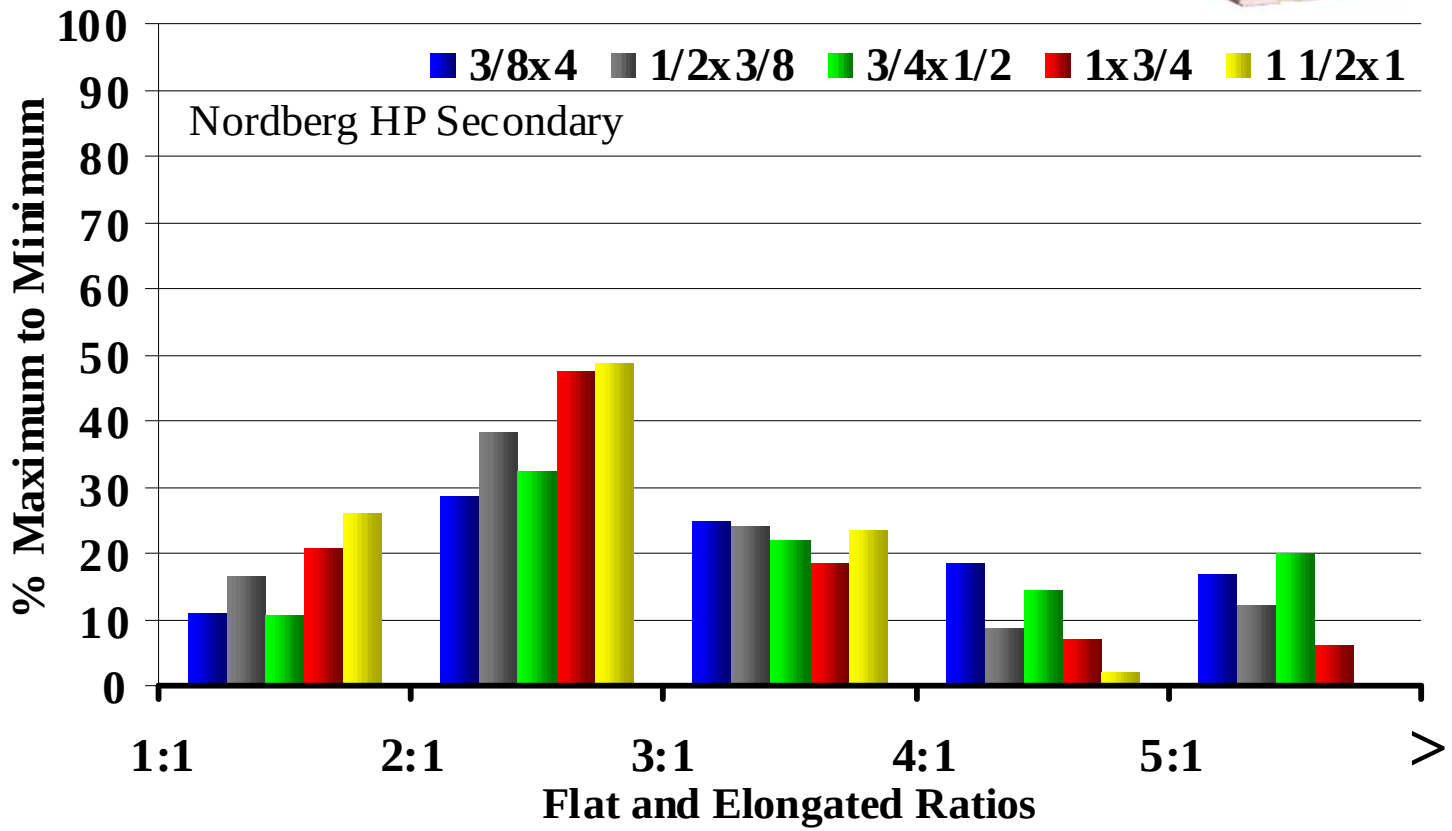
# Multiple Ratio Analysis

| | <2:1 | 2:1-3:1 | 3:1-4:1 | 4:1-5:1 | >5:1 |
|---|---|---|---|---|---|
| 1x3/4 | 28 | 53 | 17 | 2 | |
| 3/4x1/2 | 33 | 43 | 13 | 6 | 5 |
| 1/2x3/8 | 16 | 42 | 22 | 14 | 6 |
| 3/8x#4 | 10 | 43 | 29 | 9 | 9 |

# MRA Testing Device



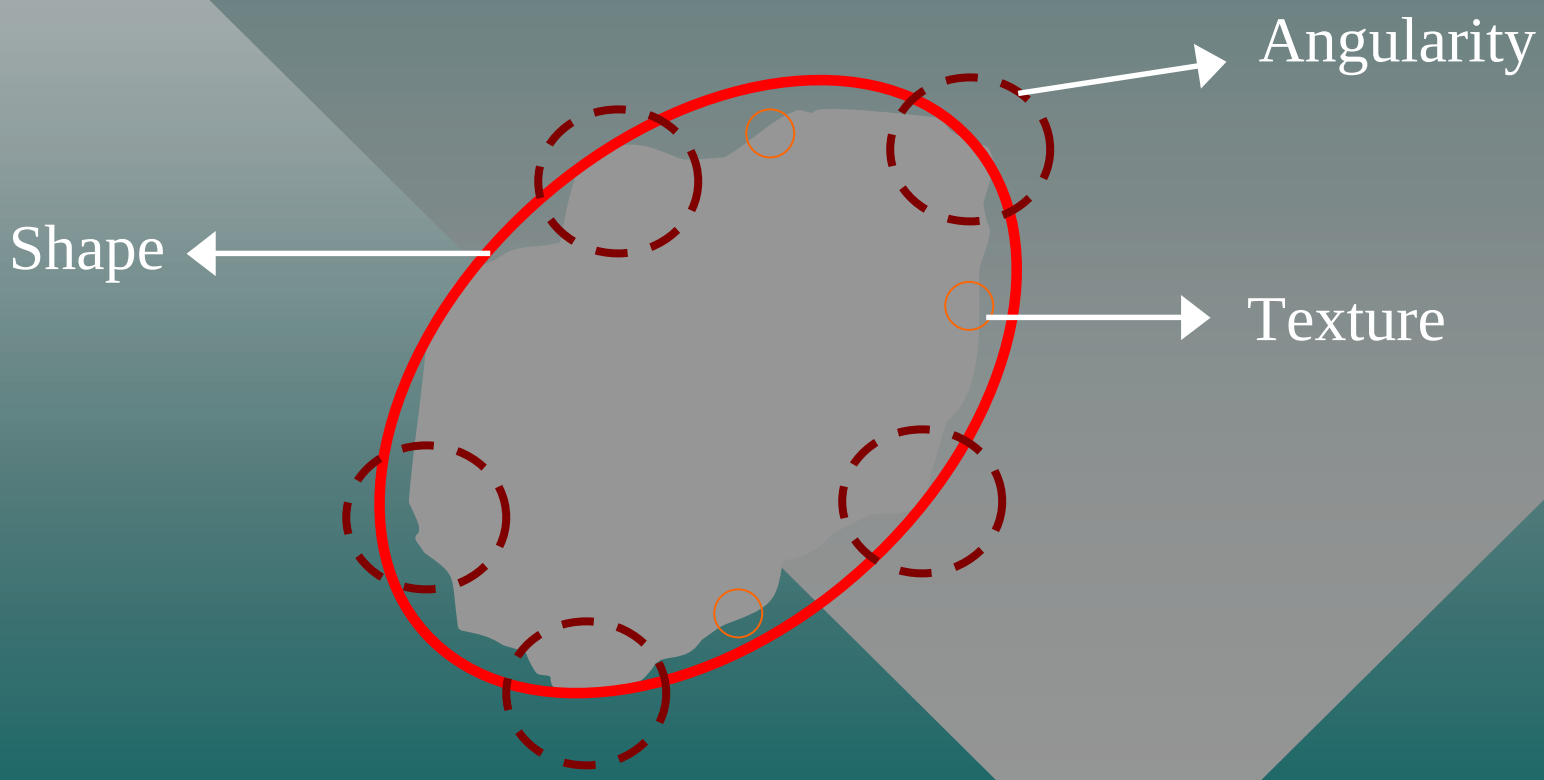
# Secondary Crusher

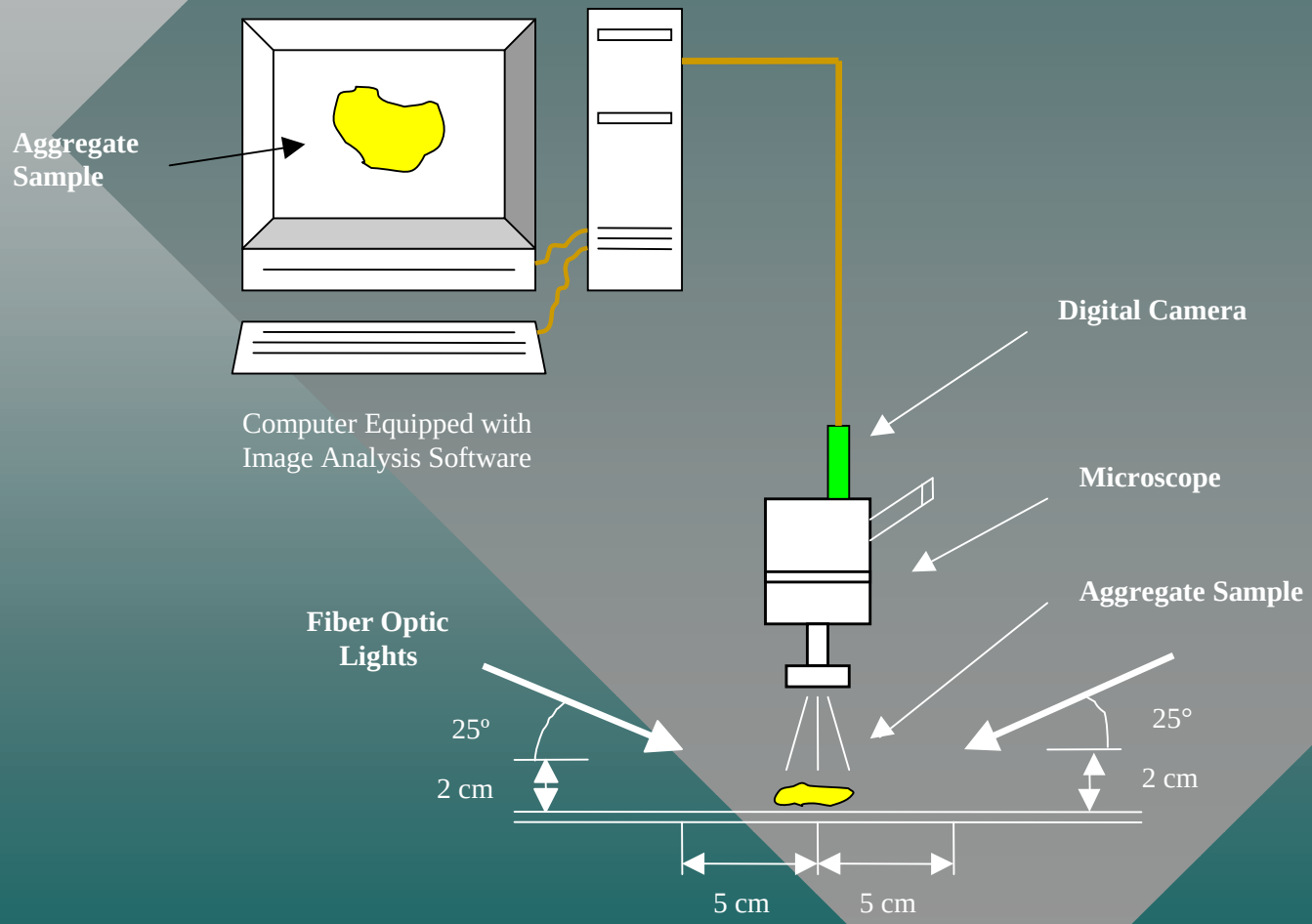
# NCHRP Project 4-30

Test Methods for Characterizing Aggregate Shape, Texture and Angularity

# Aggregate Shape Indices



# Image Acquisition Setup



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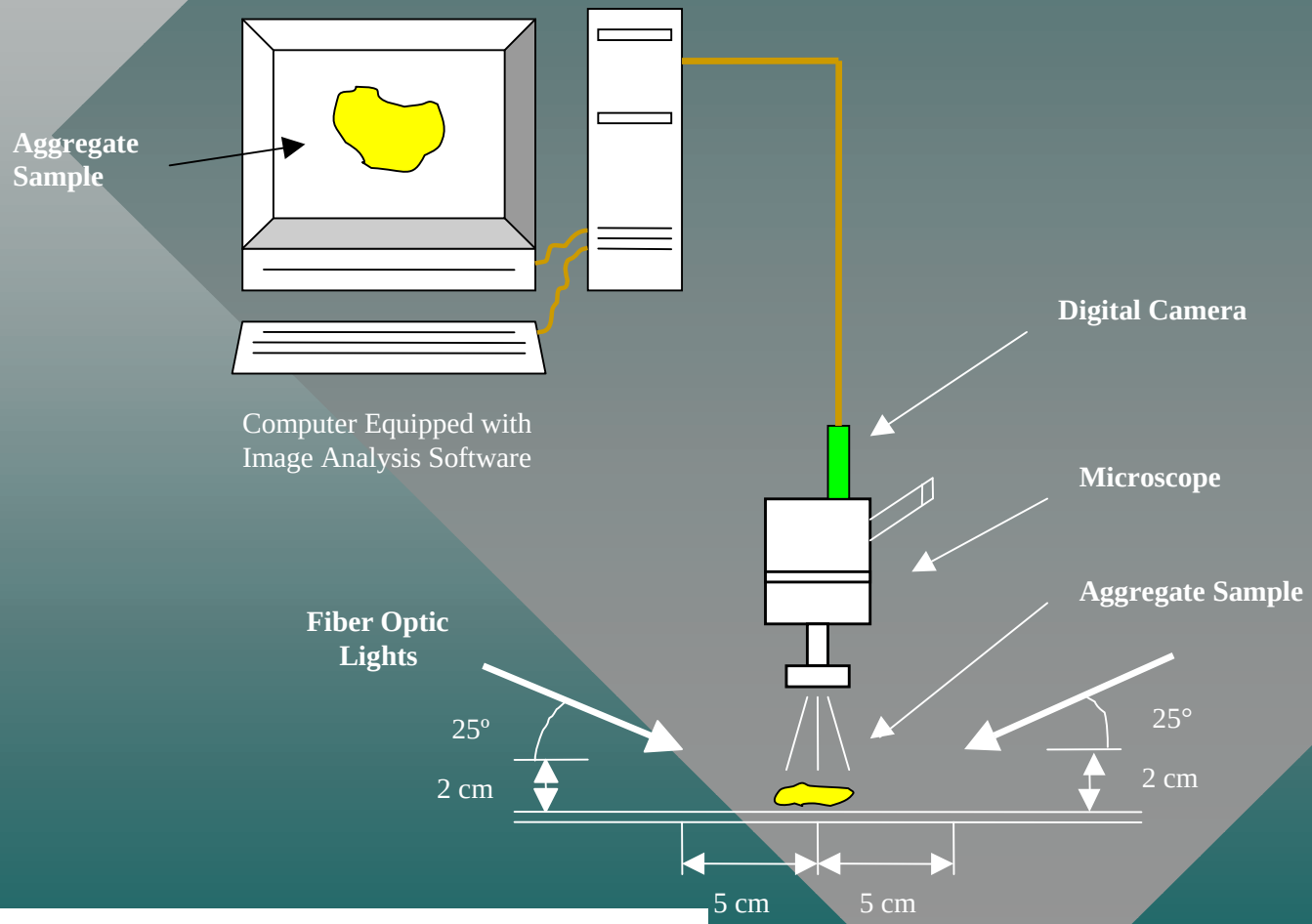


Multiple Ratio Sphericity

# Fine Aggregate Requirements

- Natural sand content < 15%
- Sand equivalent > 45
- Uncompacted voids > 45
- Clay lumps and friable particles- 0.3% max

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- Sand equivalent > 45
- Natural sand content < 15%
- Uncompacted voids > 45
- Clay lumps and friable particles- 0.3% max

# Fine Aggregate Requirements

- Sand equivalent > 45

Clay or clay-like fines

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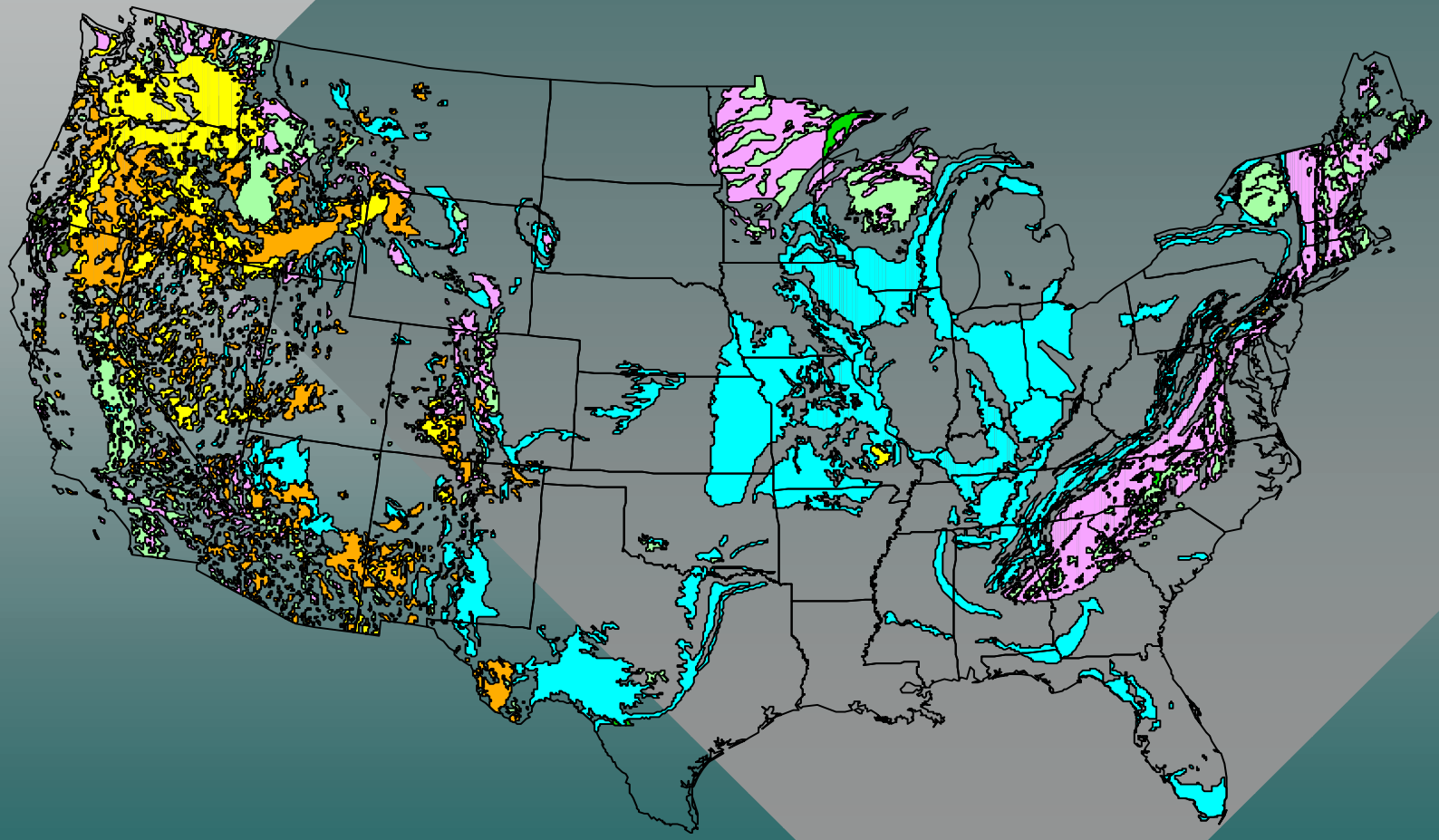
- Sand equivalent > 45

Clay or clay-like fines

Some fine-grained granites may fail this requirement due to very fine "dust of fracture" particles- not clay contamination.

# Surface Geology



# Fine Aggregate Requirements

- Natural sand content < 15%

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- Natural sand content < 15%

Should be a "safe" amount, but may not be best value.

# Fine Aggregate Requirements

- Uncompacted voids > 45

Superpave's

Fine Aggregate Angularity (FAA) Test

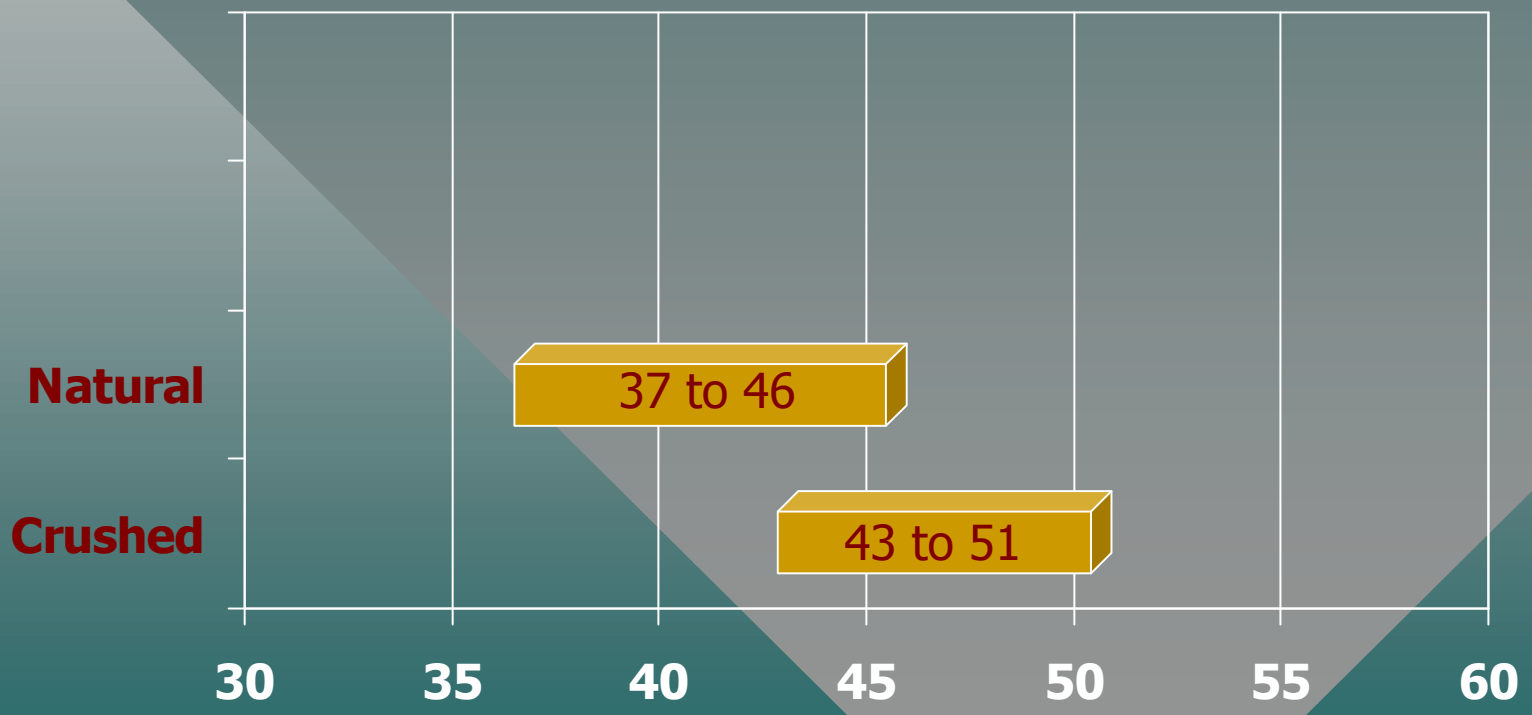
SPECIFICATION NOTE:

"The lower limit for uncompacted void content should be set at 45 for fine aggregate angularity unless local experiences indicate that a lower value can be used.

There are some aggregates which have a good performance record and have an uncompacted void content less than 45.

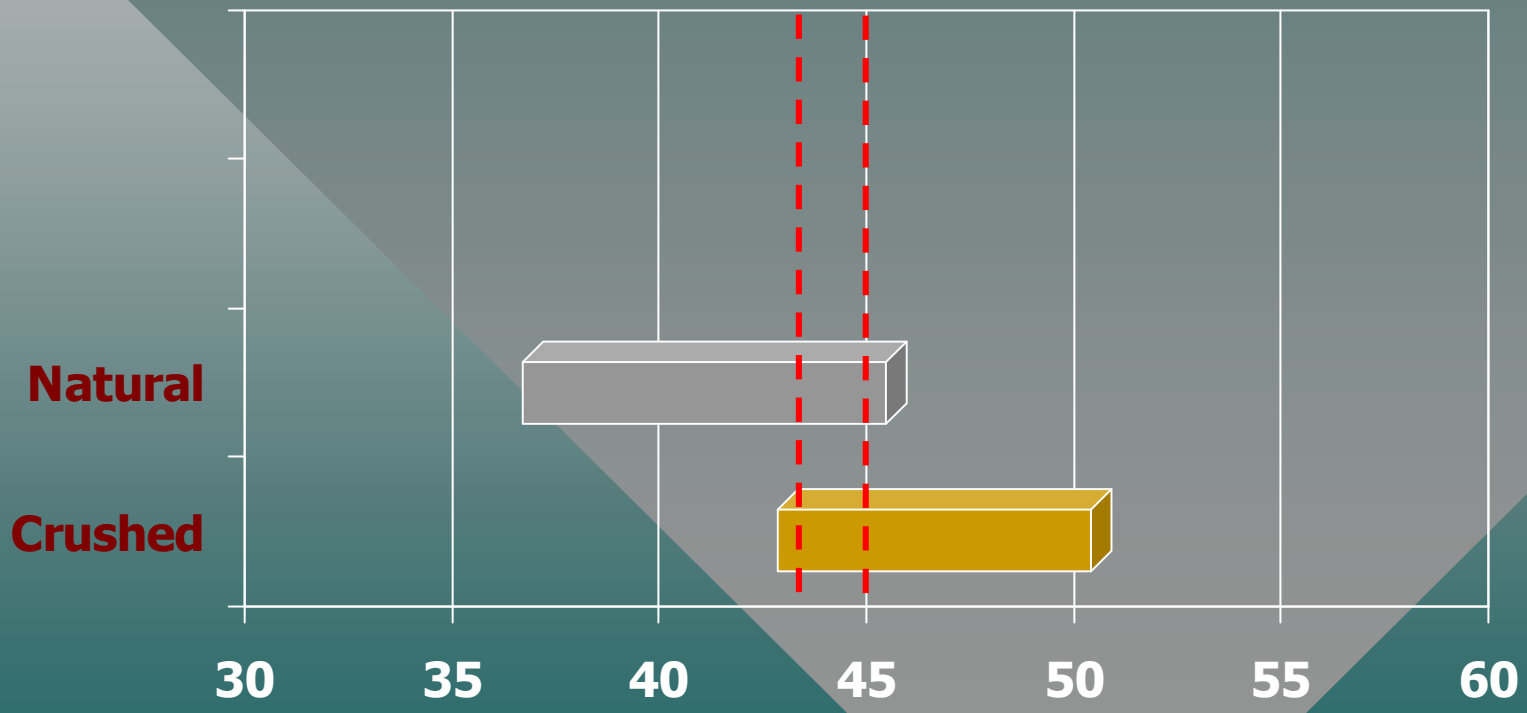
In no case should the limit be set less than 43."

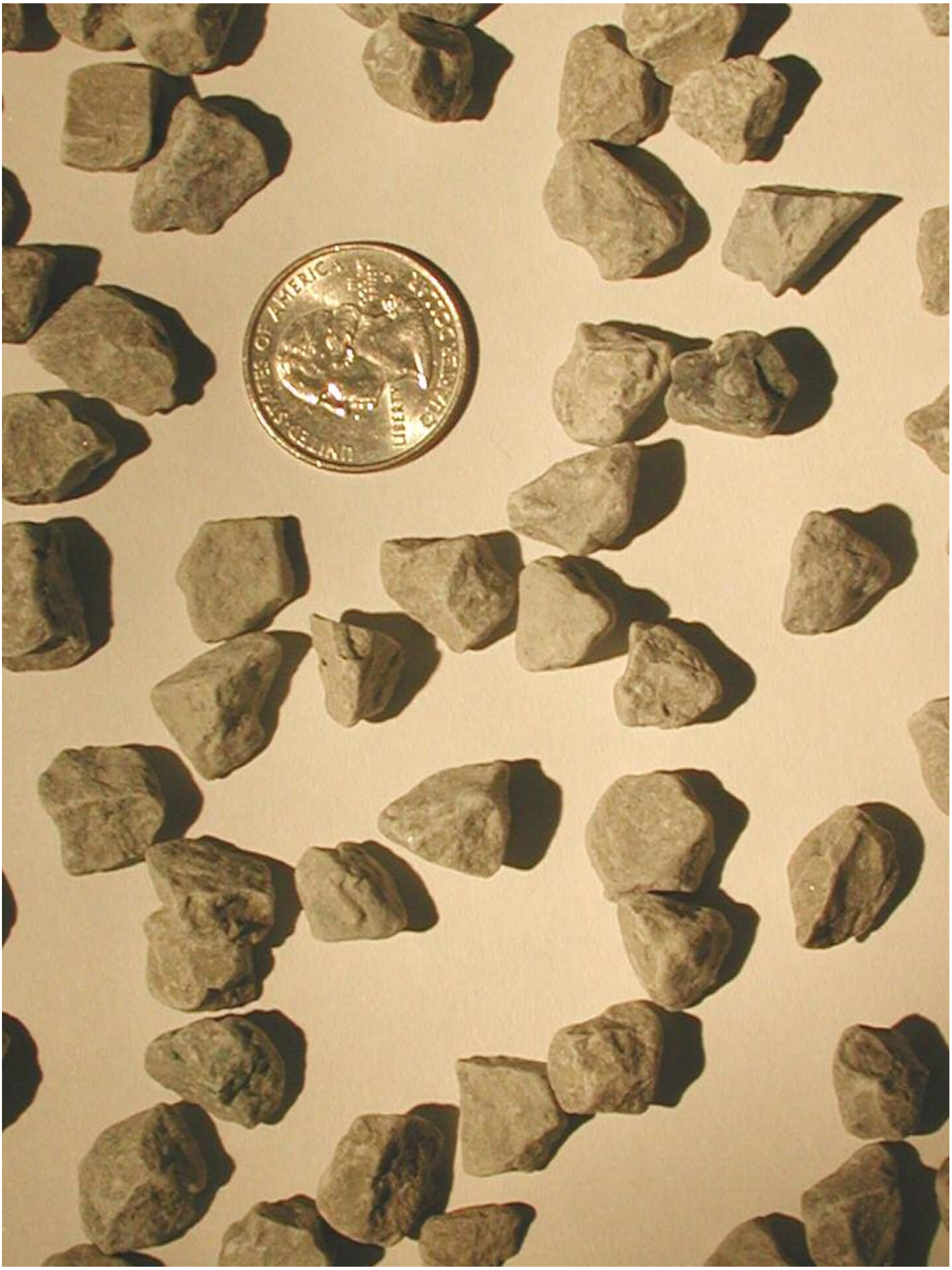
# Typical Range of FAA Values

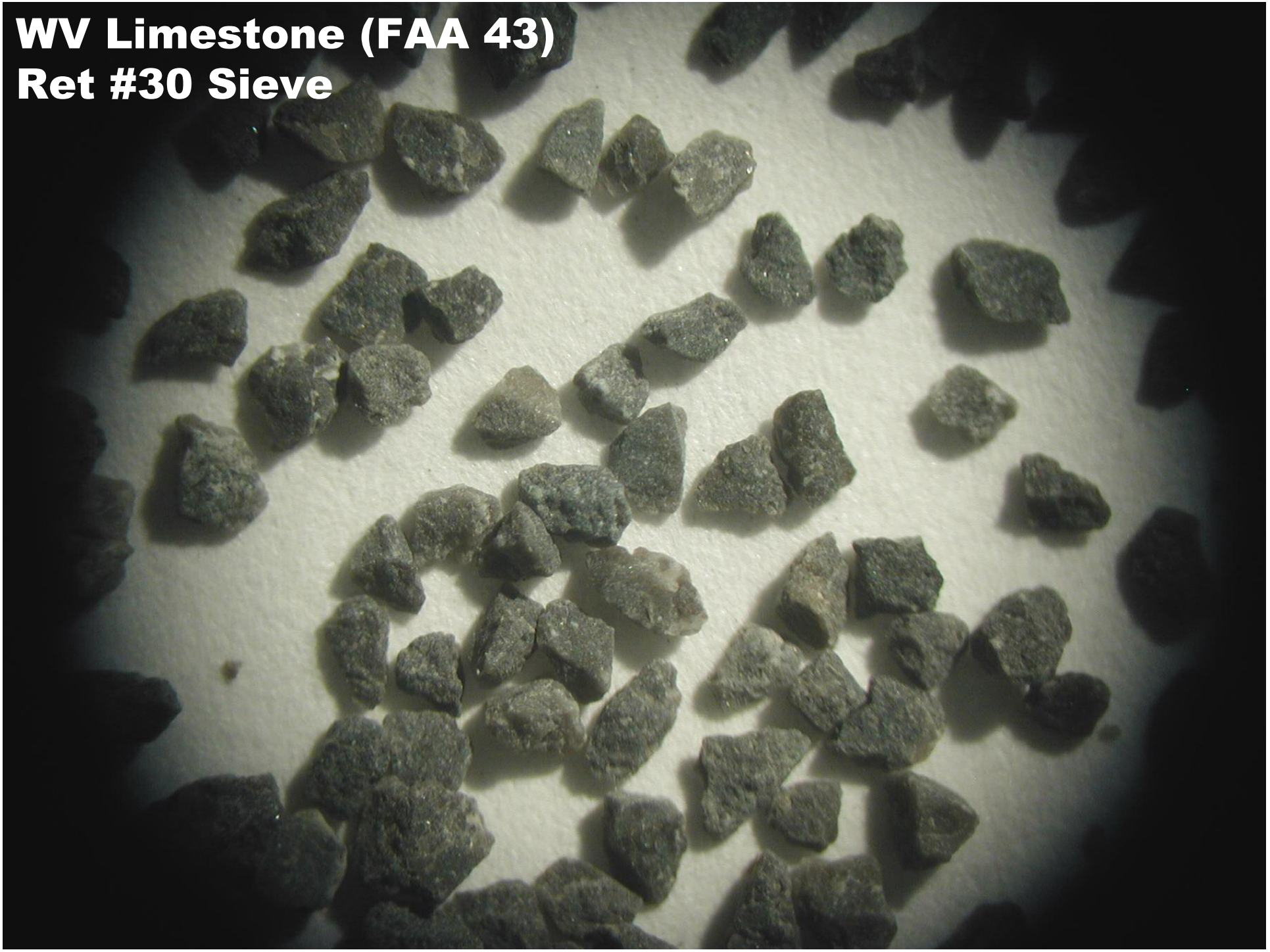


# Typical Range of FAA Values

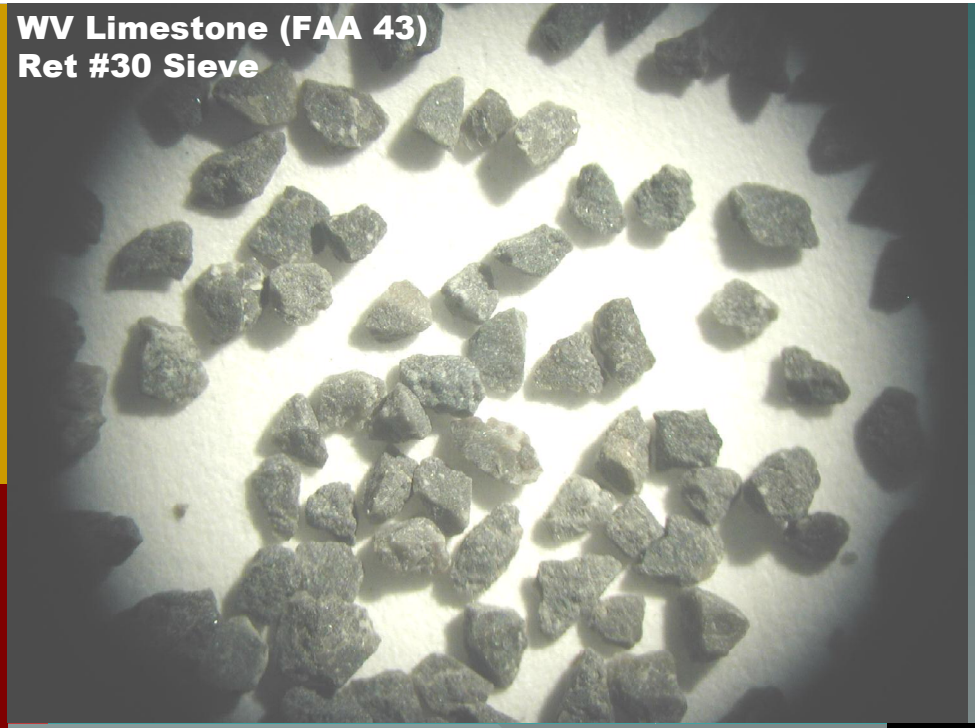
***100% crushed particles in the 43 to 45 range are highly cubical***






WV Limestone (FAA 43)
Ret #30 Sieve

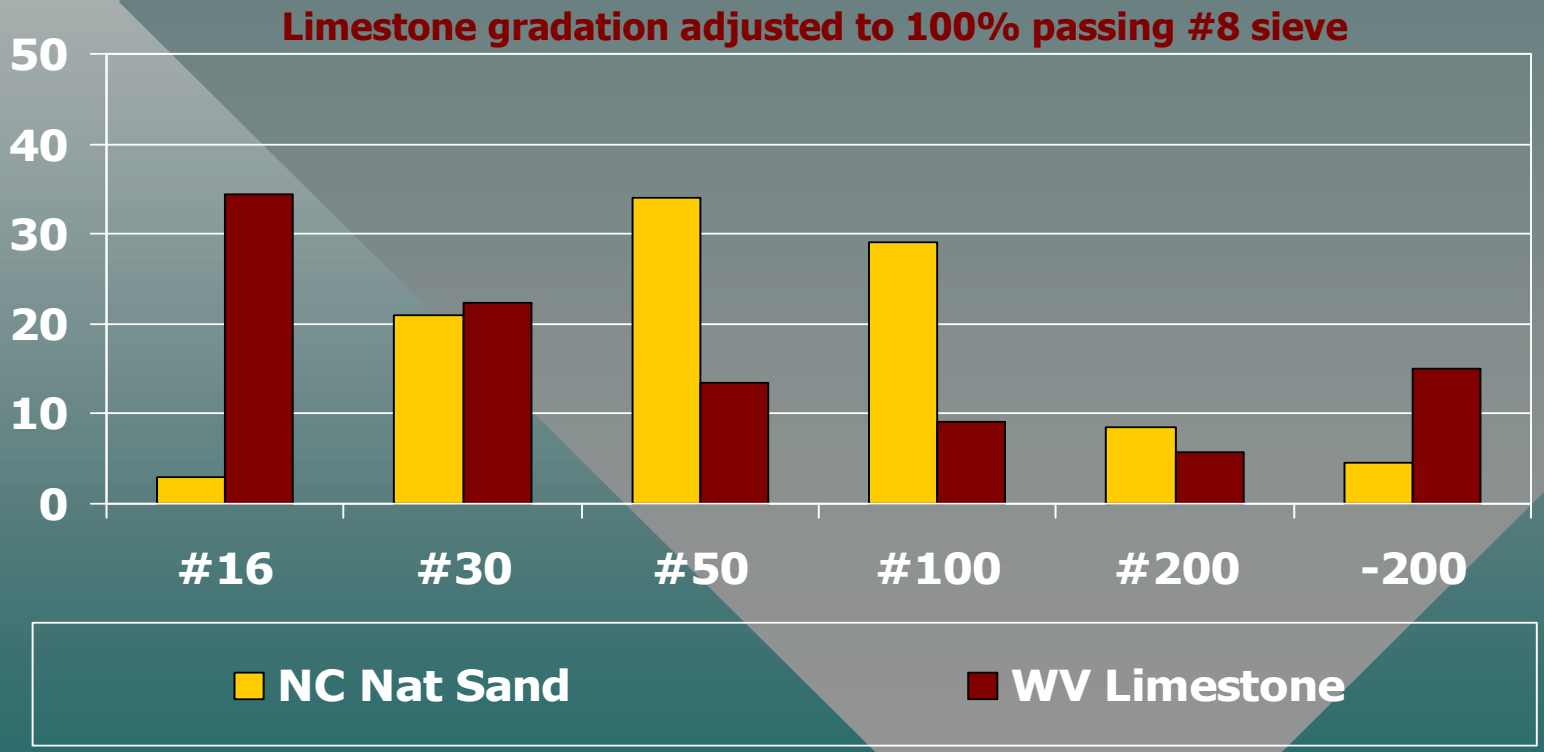

NC Natural Sand (FAA 44)
Ret #30 Sieve



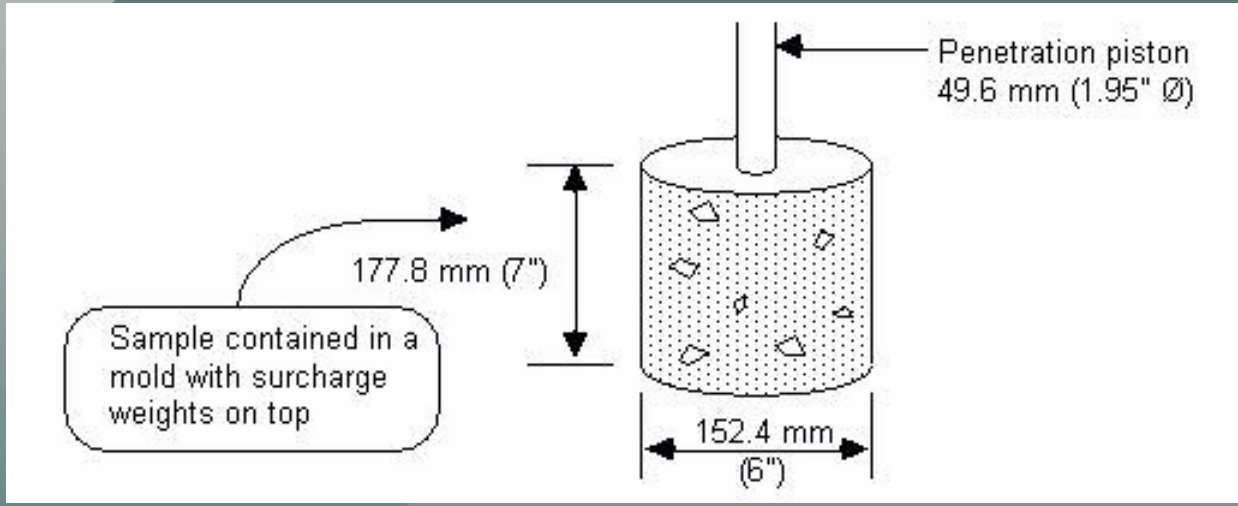

There are similarities in particle shape, surface texture, and angularity. However, the natural sand has a "humped" gradation while the limestone has a "long, well-graded" gradation.

The well-graded gradation causes a difference in performance.

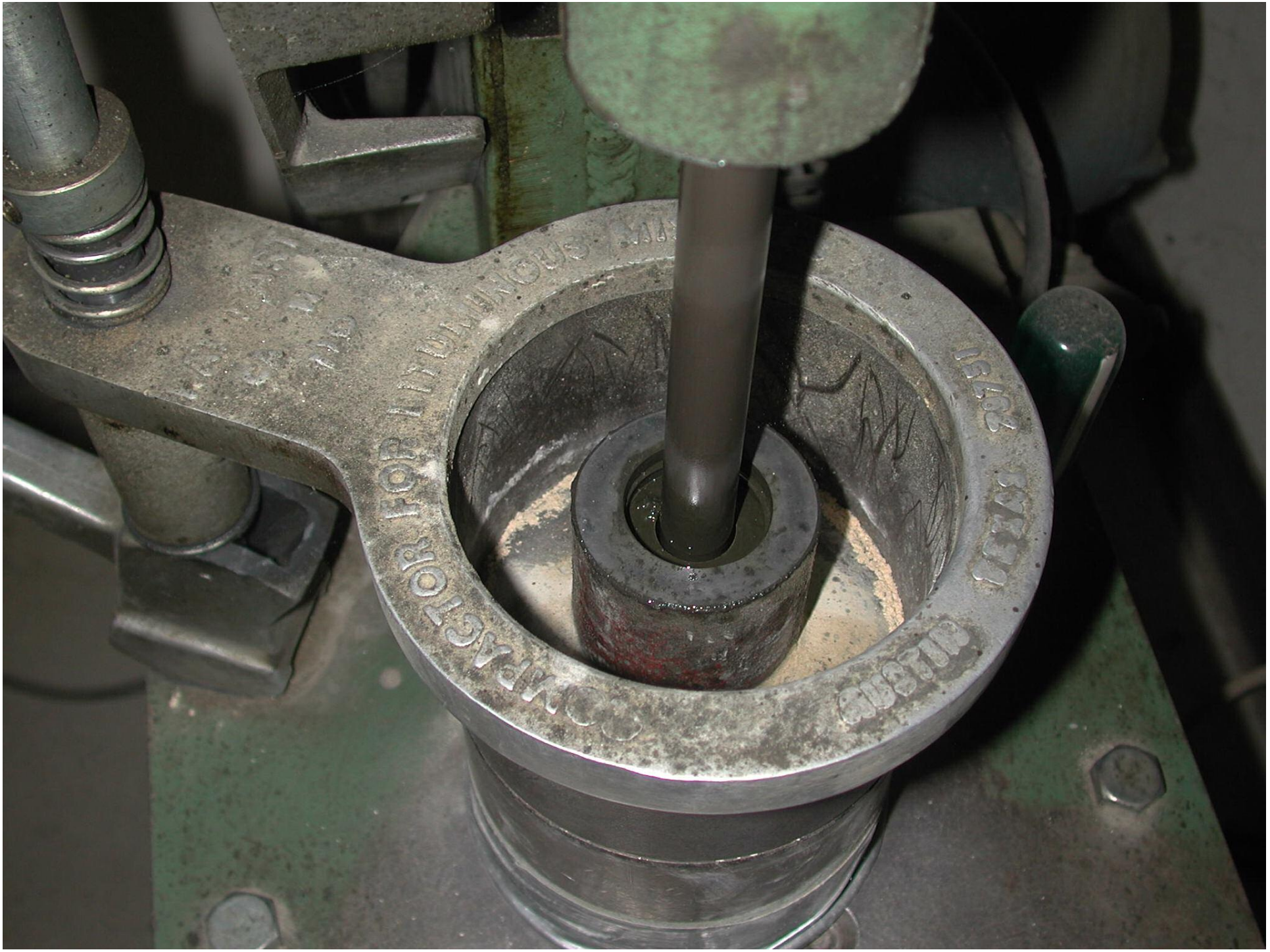
# Fractional Particle Distribution

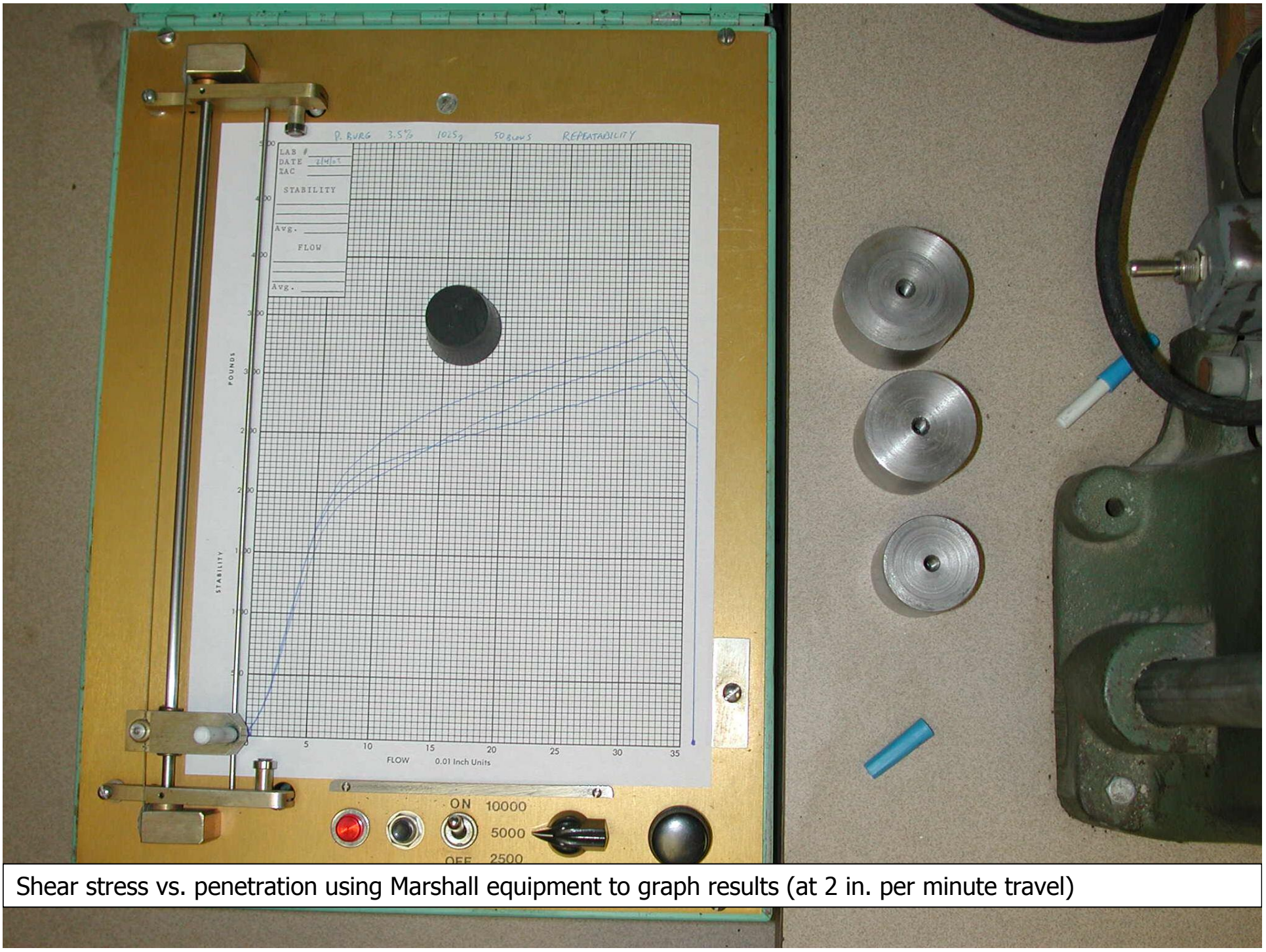


# CBR Test



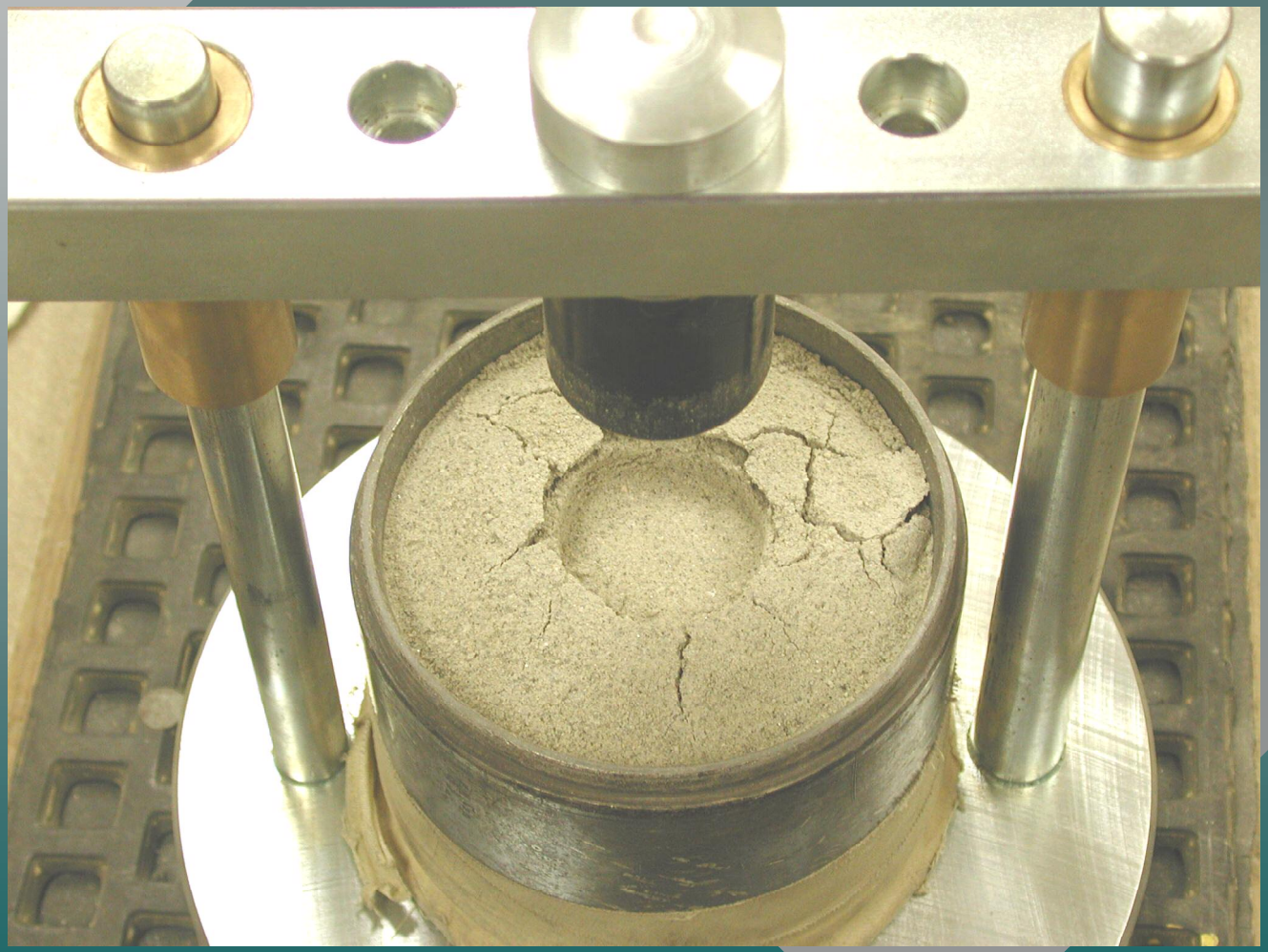

**The CBR test determines the resistance of the subgrade, (i.e. the layer of naturally occurring material upon which the road is built), to deformation under the load from vehicle wheels.**

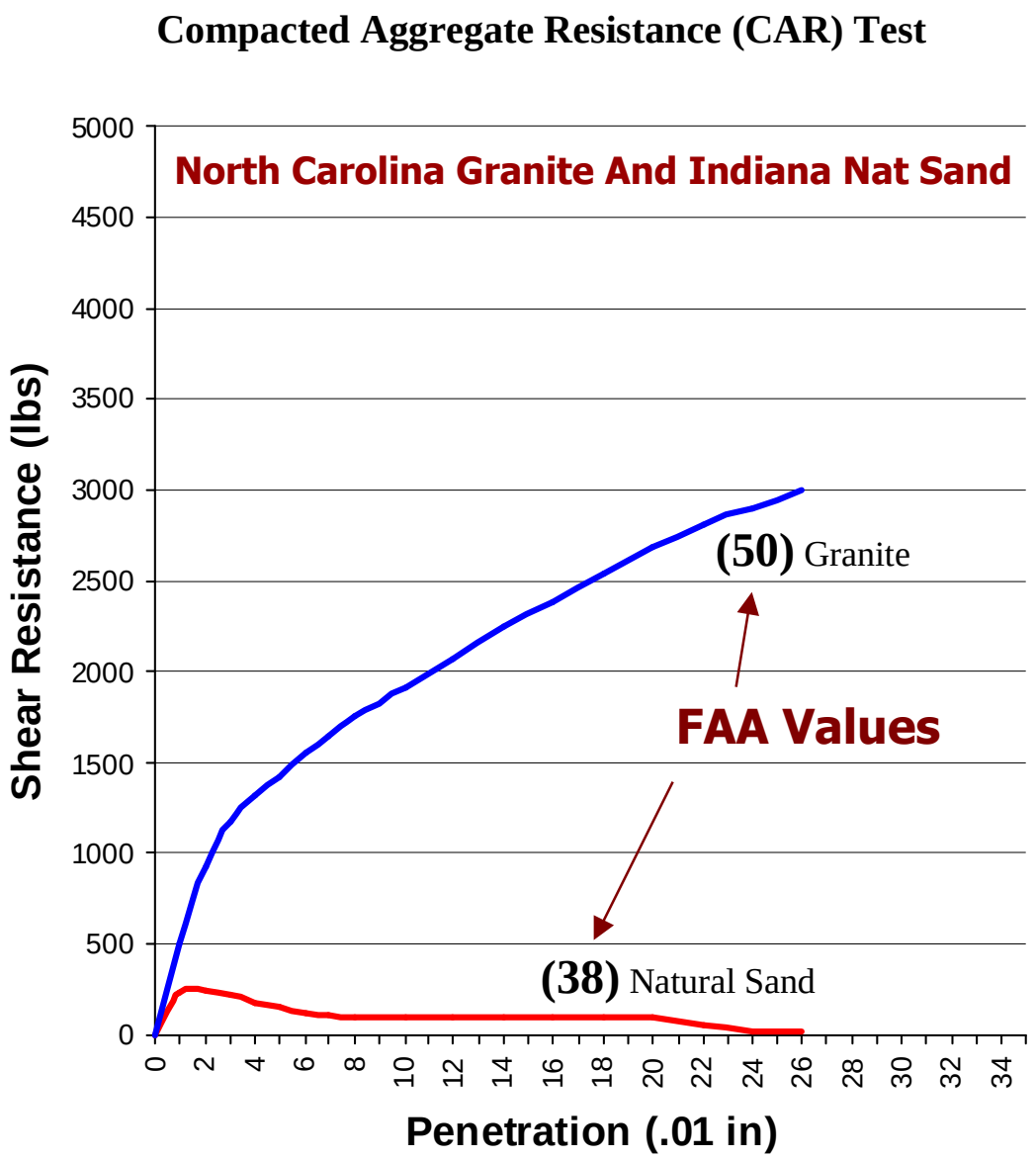

COMPACTOR FOR FIBROUS MA



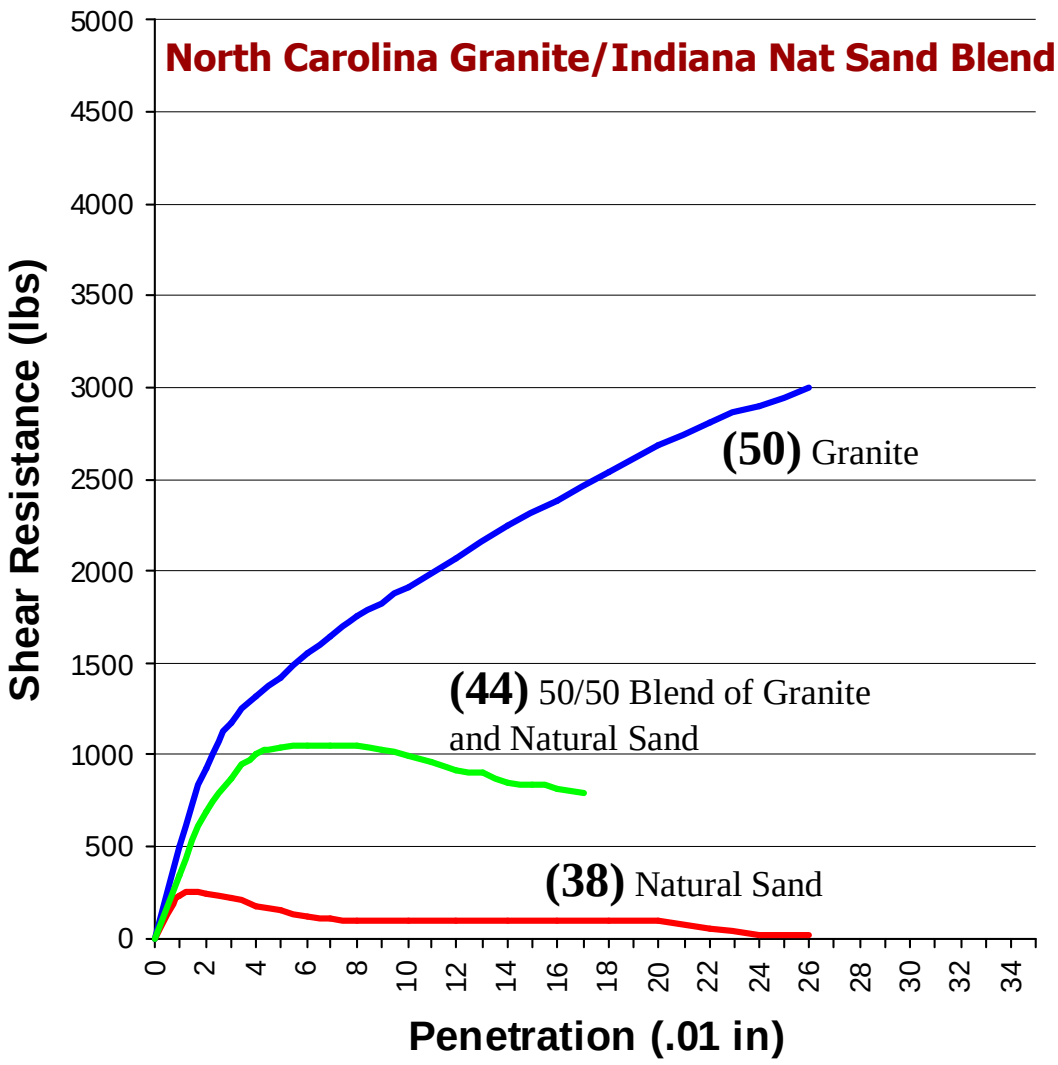

Shear stress vs. penetration using Marshall equipment to graph results (at 2 in. per minute travel)

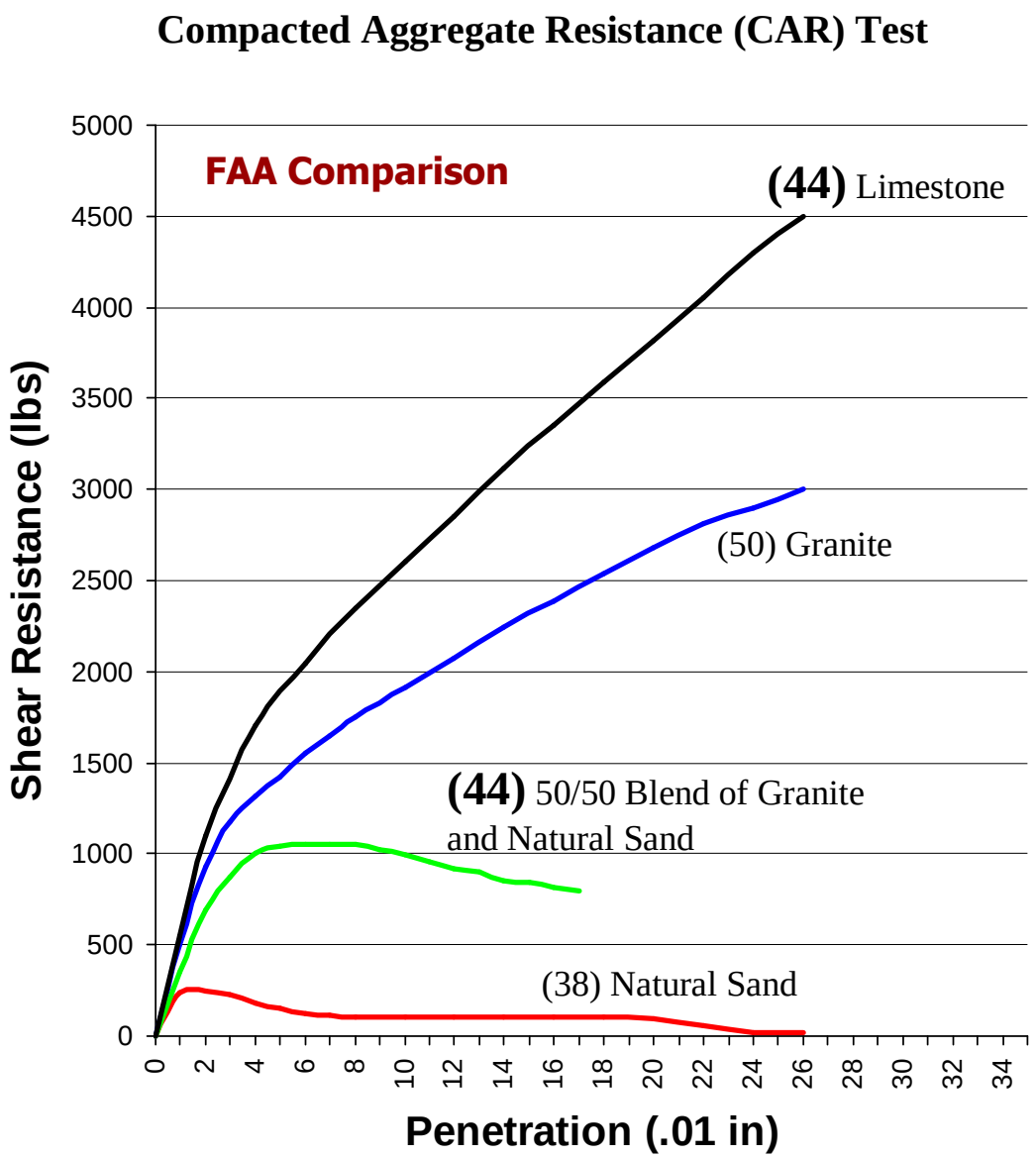
# Compacted Aggregate Resistance (CAR) Test

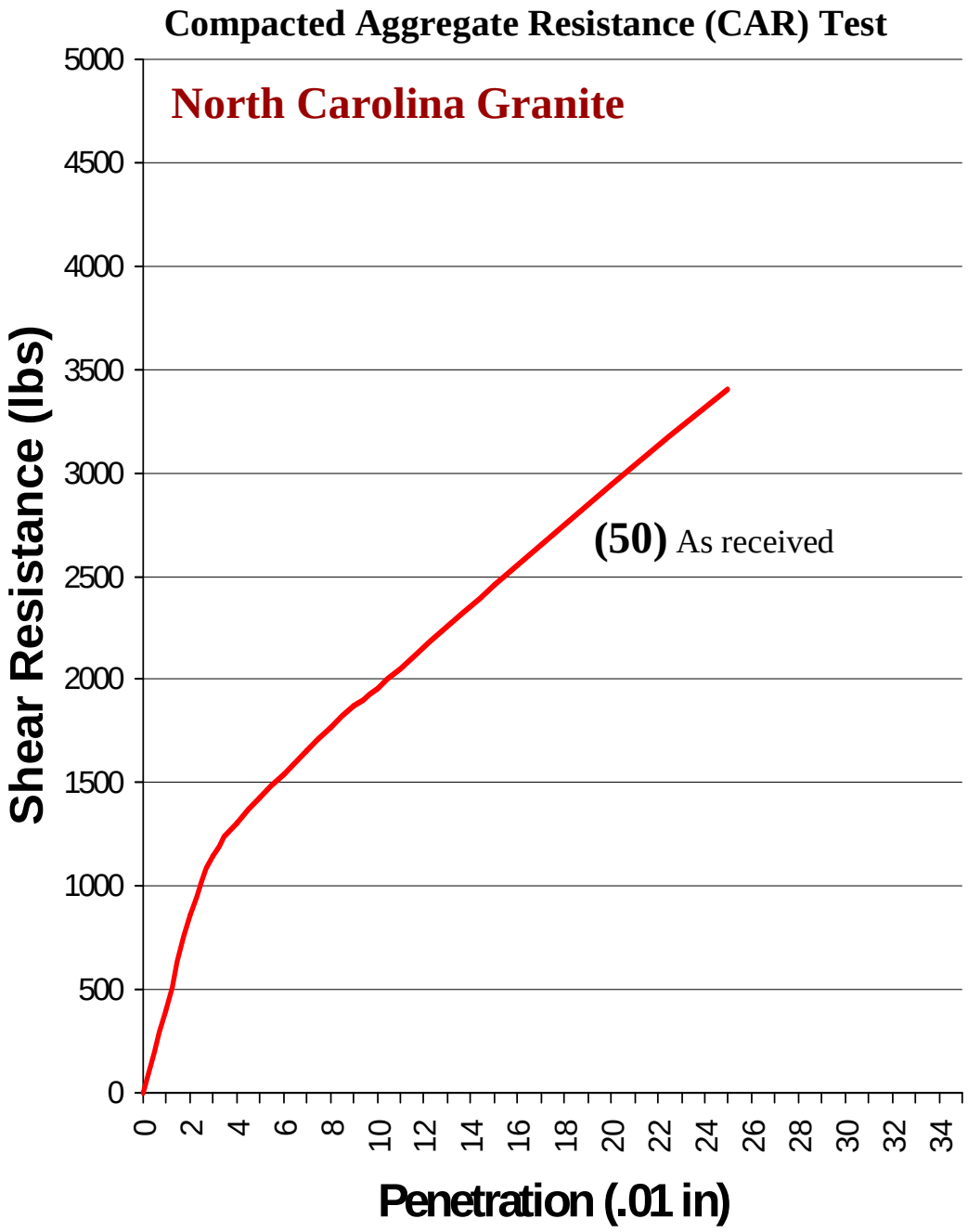


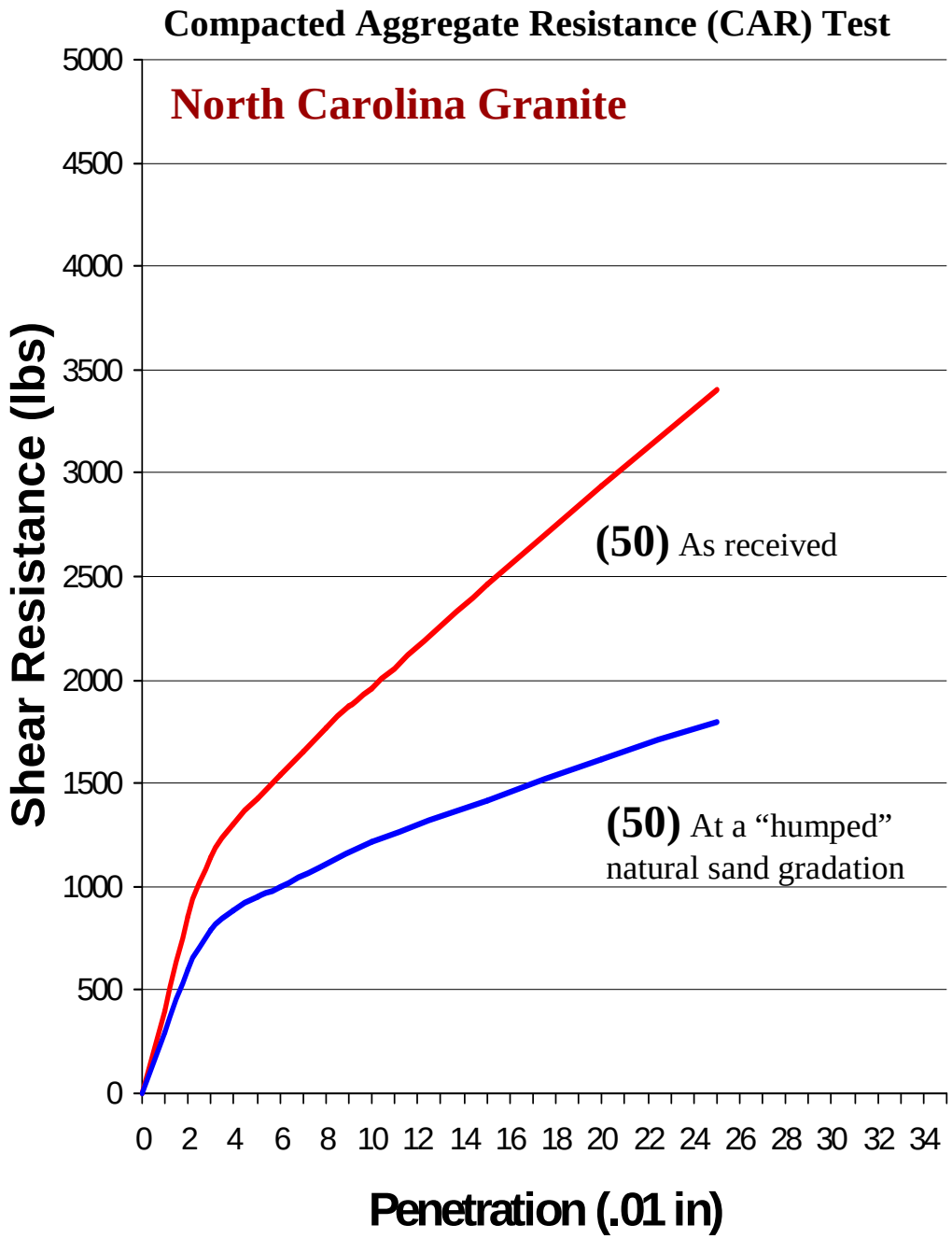

Compacted Aggregate Resistance (CAR) Test
North Carolina Granite And Indiana Nat Sand
Shear Resistance (lbs)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
(50) Granite
FAA Values
(38) Natural Sand
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
Penetration (.01 in)

## Compacted Aggregate Resistance (CAR) Test



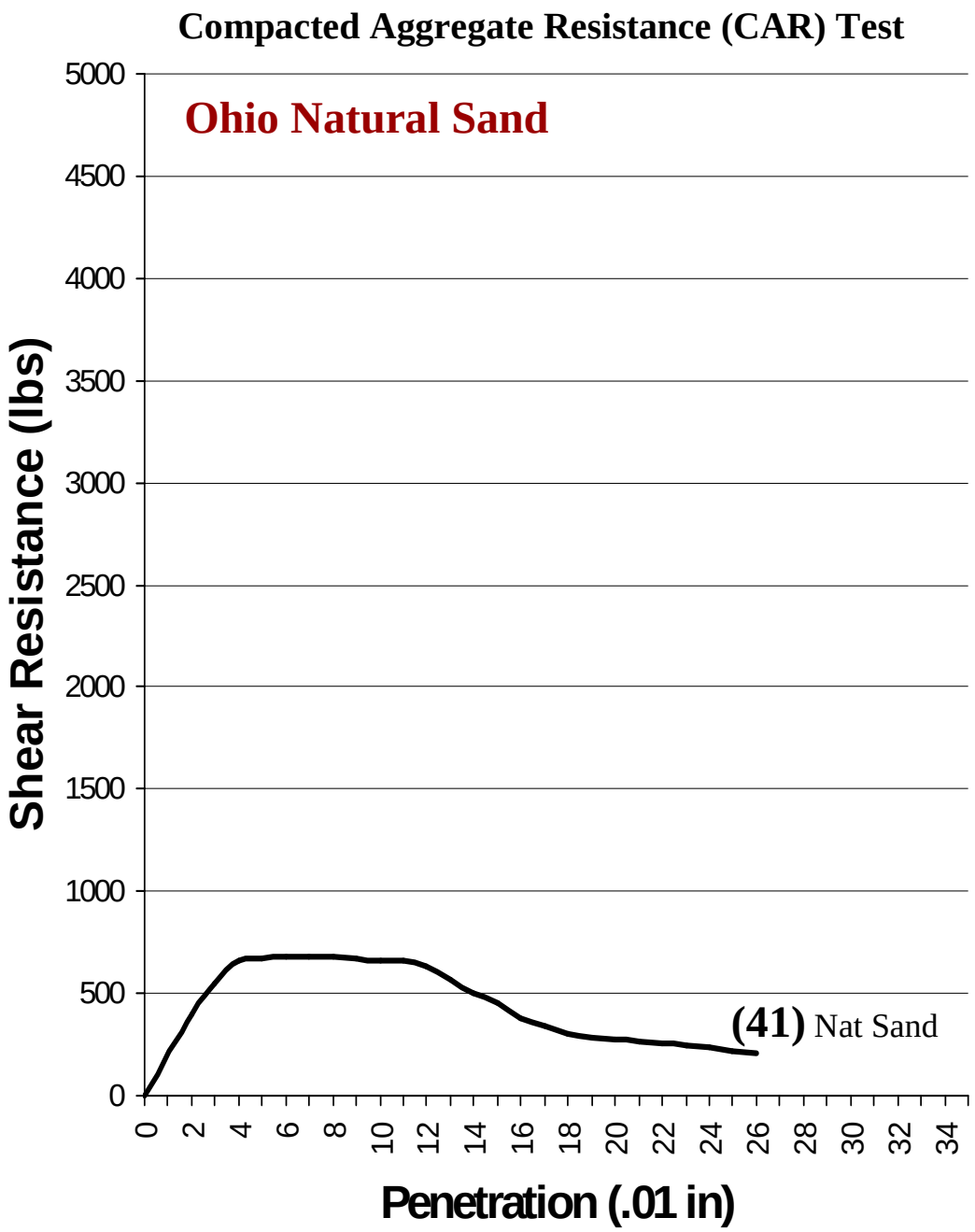

Compacted Aggregate Resistance (CAR) Test
FAA Comparison
(44) Limestone
(50) Granite
(44) 50/50 Blend of Granite and Natural Sand
(38) Natural Sand
Shear Resistance (lbs)
Penetration (.01 in)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34

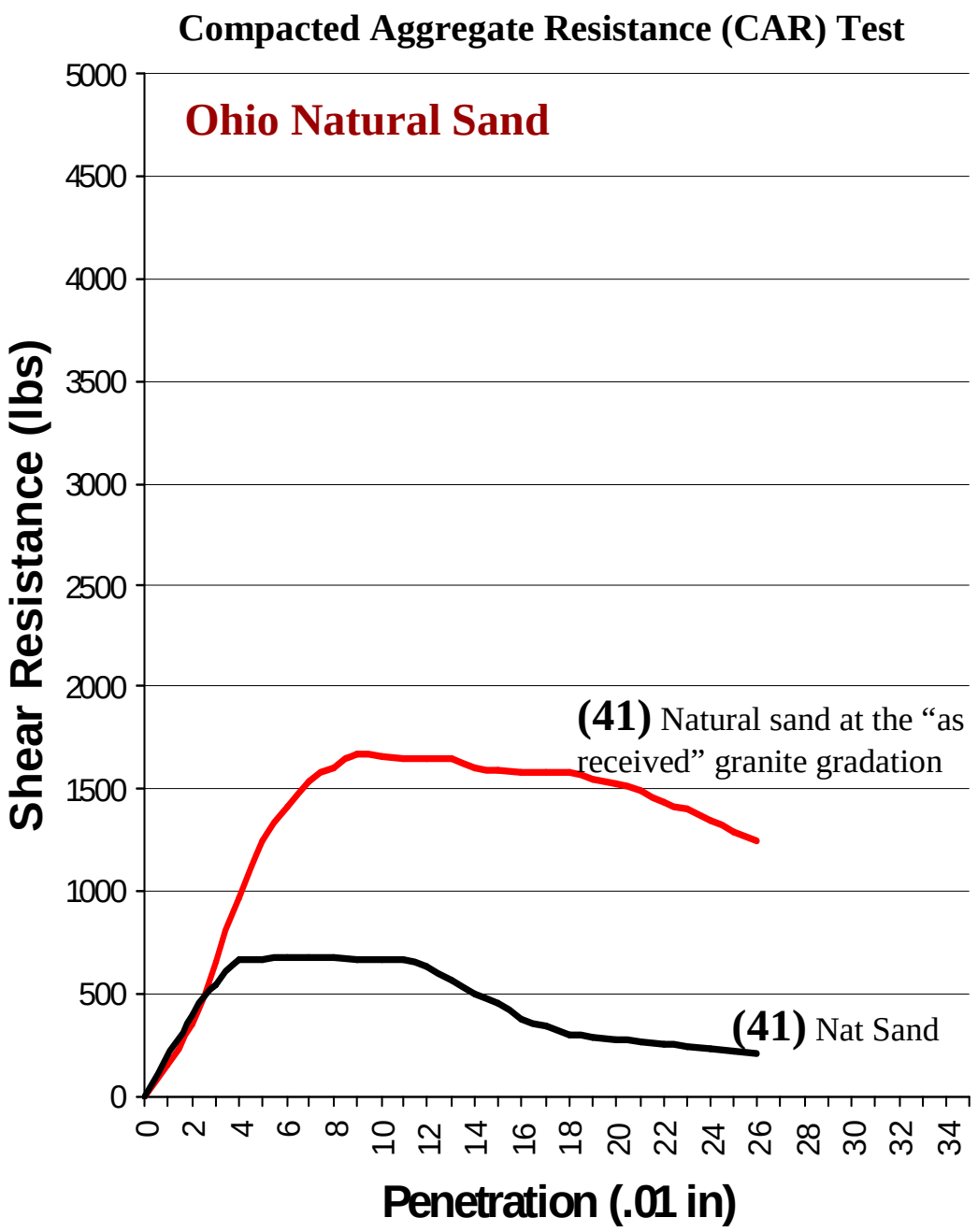

Compacted Aggregate Resistance (CAR) Test
North Carolina Granite
(50) As received
Shear Resistance (lbs)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
Penetration (.01 in)




The granite was hand batched in the lab to produce a humped natural sand gradation.

Note that particle shape and surface texture remains constant.

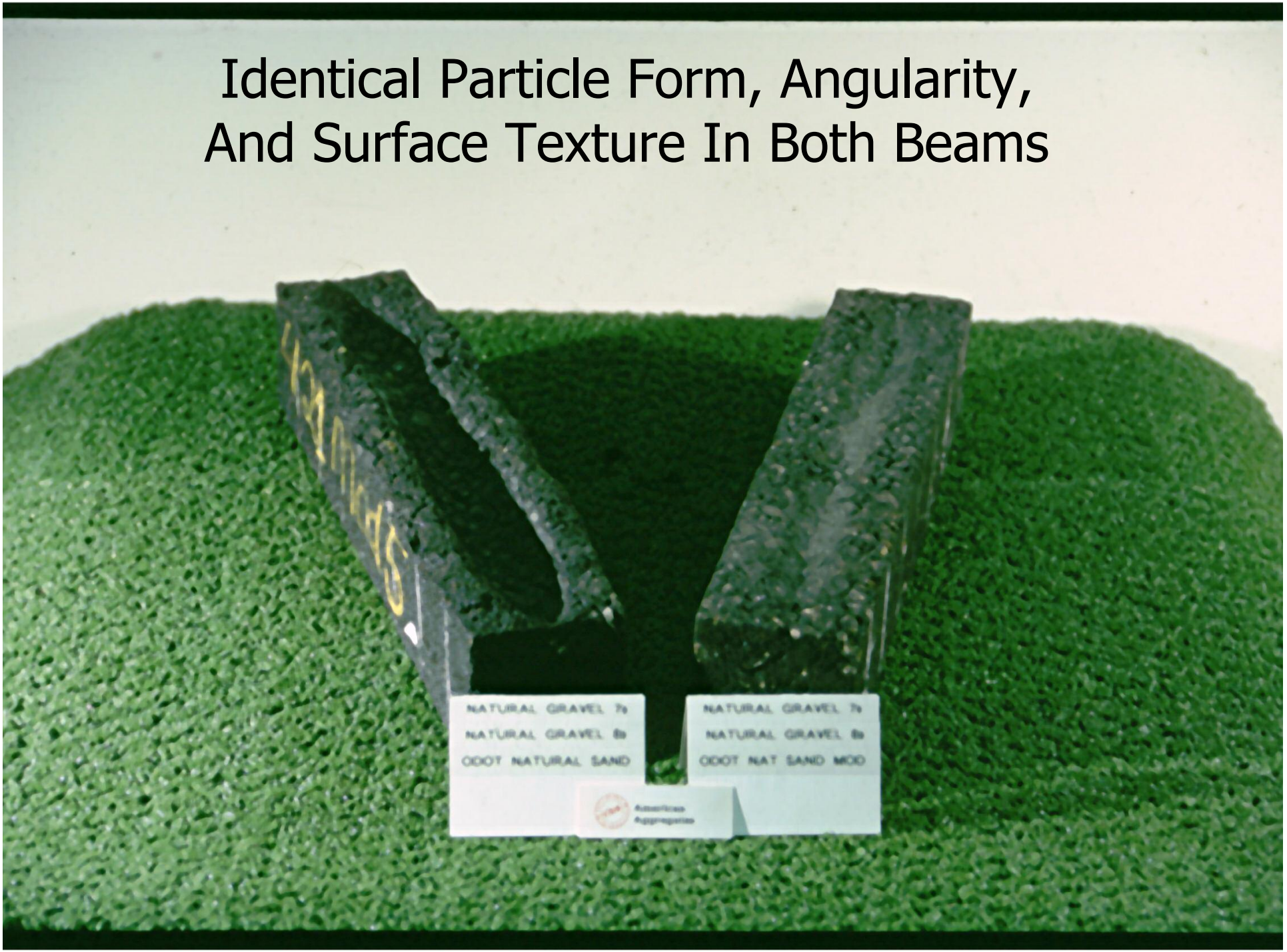

Compacted Aggregate Resistance (CAR) Test
Ohio Natural Sand
Shear Resistance (lbs)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
Penetration (.01 in)
(41) Nat Sand



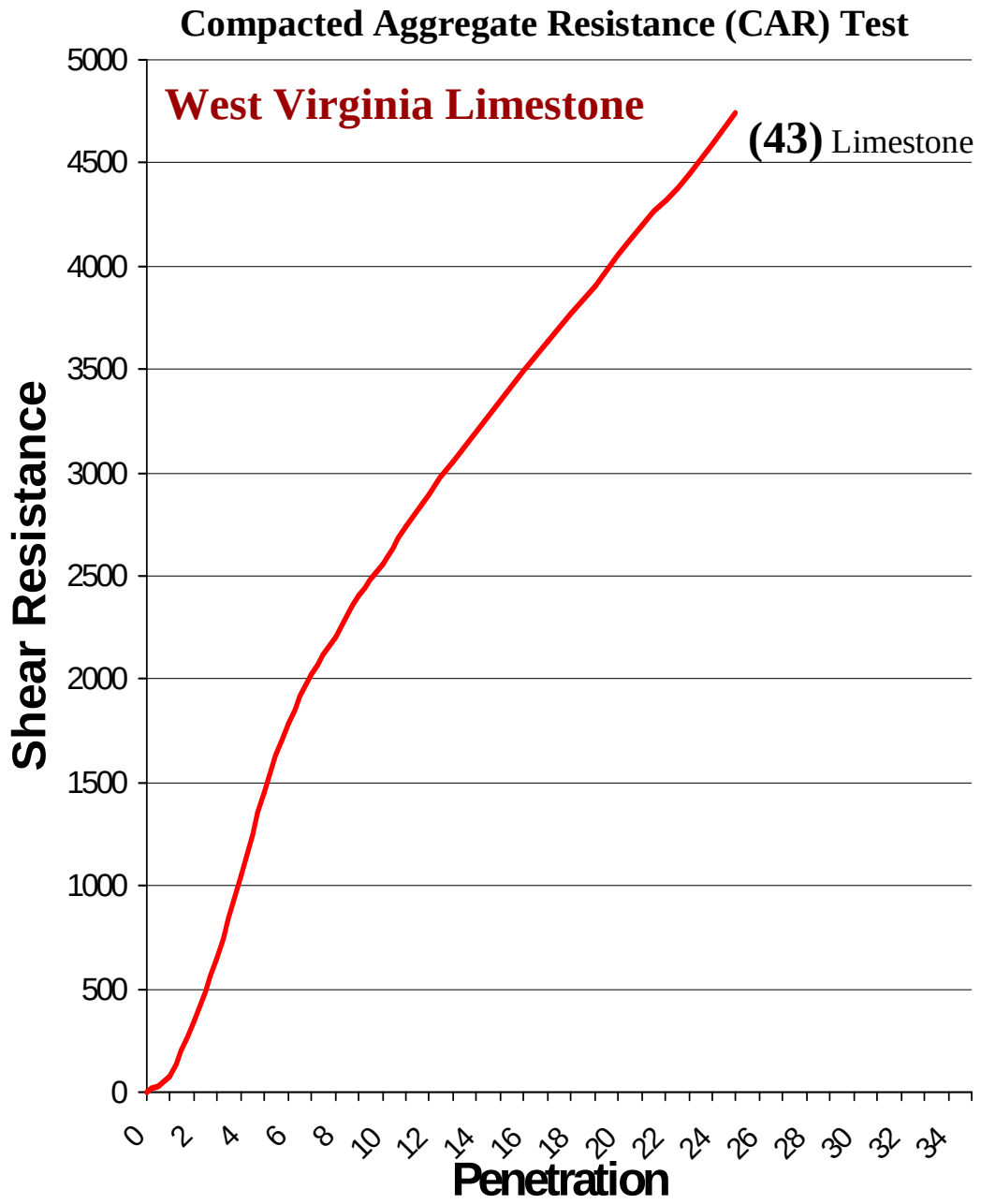

The natural sand was hand batched in the lab to produce a "long graded" granite gradation.

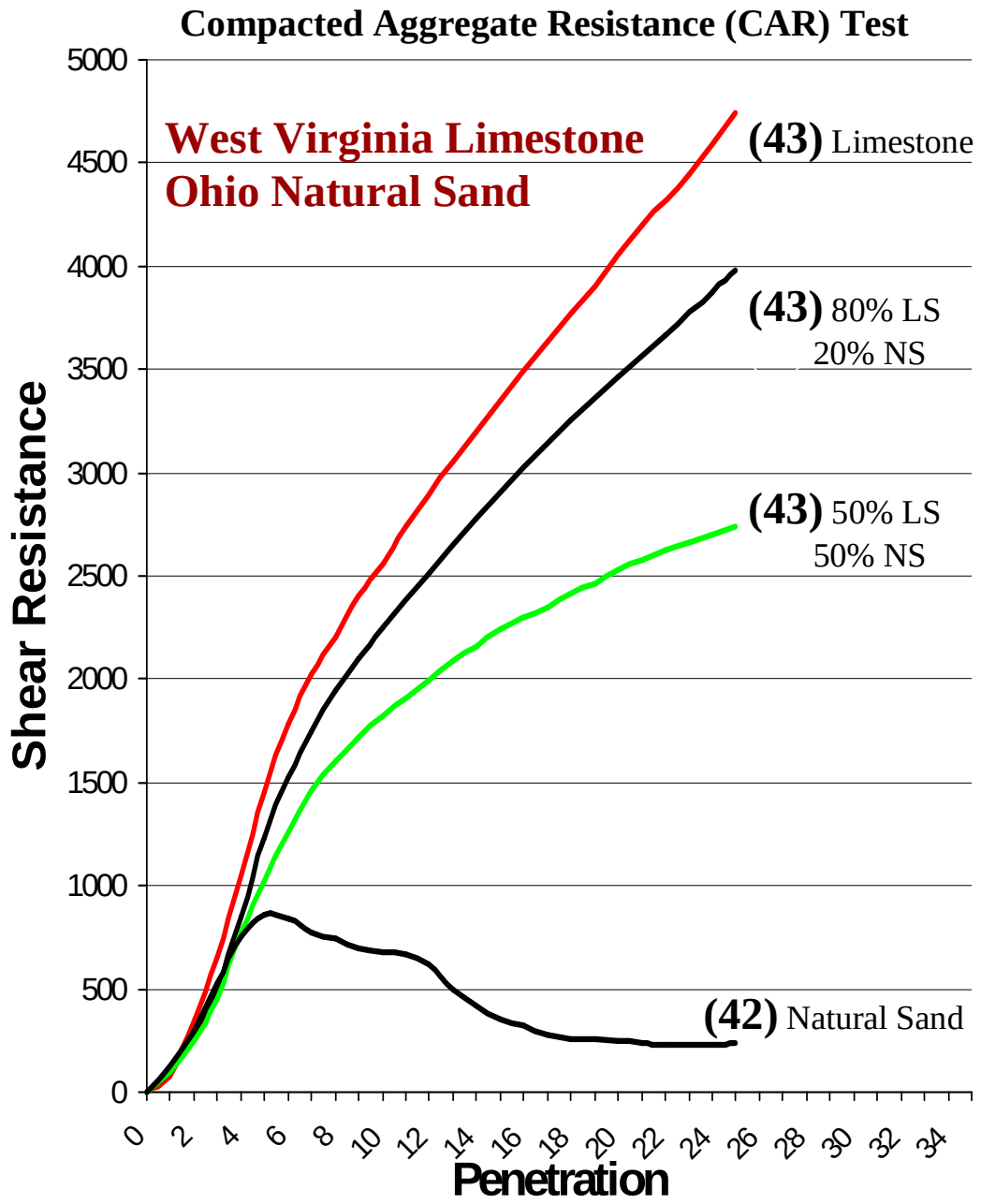
Note that particle shape and surface texture remains unchanged.

# Identical Particle Form, Angularity, And Surface Texture In Both Beams

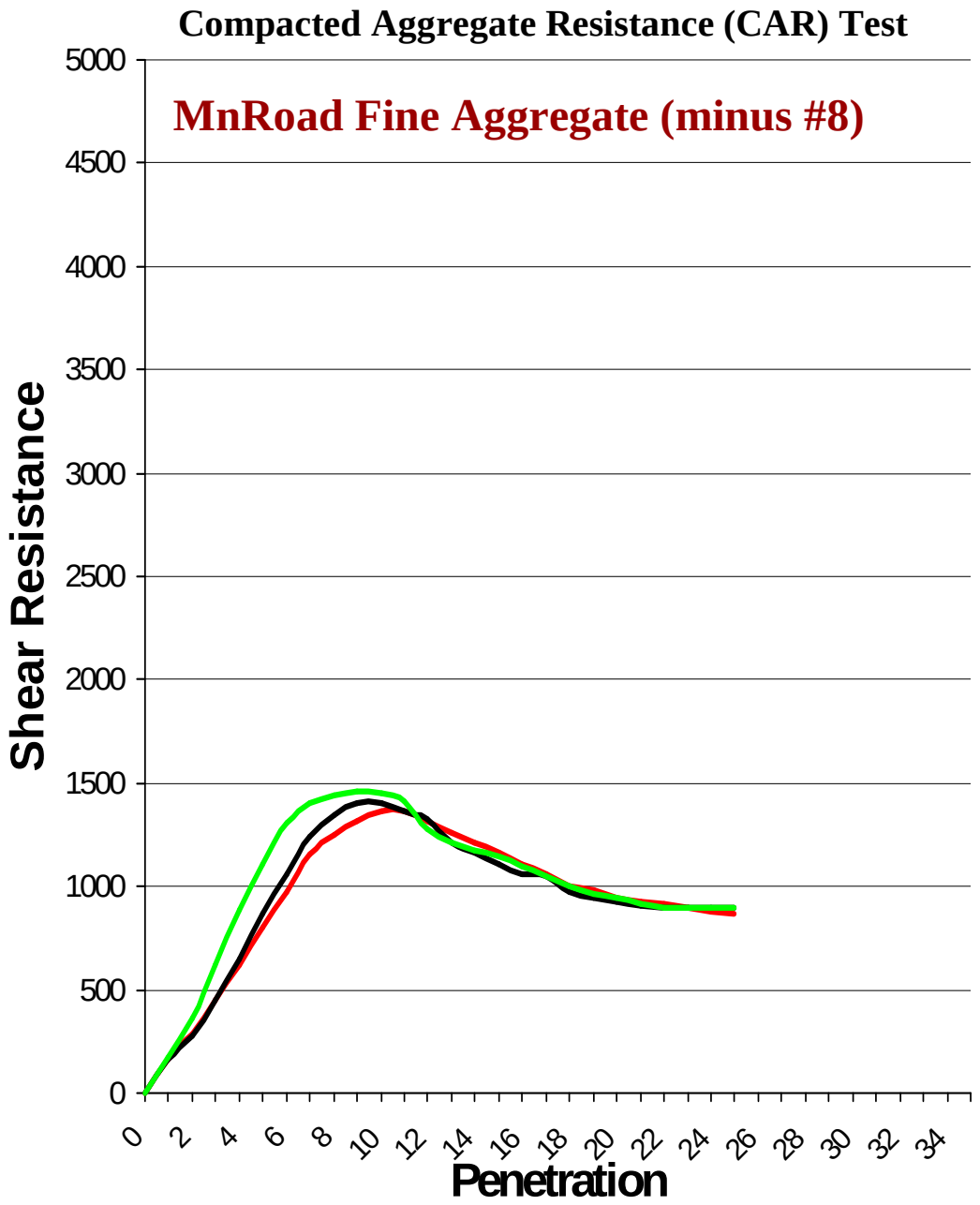



WV Limestone (FAA 43)
Ret #30


Compacted Aggregate Resistance (CAR) Test
West Virginia Limestone
(43) Limestone
Shear Resistance
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34
Penetration


Compacted Aggregate Resistance (CAR) Test
West Virginia Limestone
Ohio Natural Sand
(43) Limestone
(43) 80% LS
20% NS
(43) 50% LS
50% NS
(42) Natural Sand
Shear Resistance
Penetration
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34


MnRoad Fine Agg
(FAA ??) Ret #30


Compacted Aggregate Resistance (CAR) Test
MnRoad Fine Aggregate (minus #8)
Shear Resistance
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
Penetration

# 3.3 PREPARATION OF HOT-MIX ASPHALT MIXTURE

"The aggregates and the asphalt cement shall be weighed or metered and introduced into the mixer in the amount specified by the JMF."

# 3.3 PREPARATION OF HOT-MIX ASPHALT MIXTURE

In reality, deviations at the cold feeds from percentages shown on the JMF are normal.

Deviations from the JMF are used to compensate for some breakdown of the aggregate, which is normal.


NC Granite (FAA 50)
Ret #30

# FAA Changes From Production Process For Highly Angular Granite

| | FAA Value |
|---|---|
| Quarry Stockpile | **50** |
| Entering Drum | **47** |
| From Extraction | **46** |
| From Field Core | **46** |

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- Cut core, determine density
- Heat core and then remix to coat exposed aggregate surfaces
- Determine the Rice gravity, which is the true theoretical for the core
- Compare core density with Rice to determine true air void content
- Keep paving!

# Improper material handling can undo the benefits of sophisticated production plants

# Stockpiling

# Wright-Patterson AFB

# Stockpile Recovery

# Classroom Training On Stockpile Recovery

# Thank You!

Questions ???

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